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**Sano, Mary**

ATTENTIONAL PROCESSES IN AGING AND ALZHEIMER'S DISEASE

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# ATTENTIONAL PROCESSES IN AGING AND ALZHEIMER'S DISEASE

BY

MARY SANO

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Jan. 15, 1987
Date

Wilma Rosen
Wilma Rosen, Ph.D.
Chairman of Examining Committee

February 2, 1987
Date

Herbert D. Saltzstein
Herbert D. Saltzstein, Ph.D.
Executive Officer

Wilma Rosen, Ph.D.
Louis Gerstman, Ph.D
Jeffrey J. Rosen, Ph.D.
Richard Mayeux, M.D.
Yaakov Stern, Ph.D.
Supervisory Committee

The City University of New York

Abstract

ATTENTIONAL PROCESSES IN AGING AND ALZHEIMER'S DISEASE

by

Mary Sano

Advisor : Wilma Rosen, Ph.D.

Memory deficits are well documented in Dementia of the Alzheimer type (DAT), though little study has been given to attention. The present study examined two attentional processes (global and selective) in DAT patients, elderly controls and young controls using a modification of the Posner and Bois (1970) model of attention. The first component, a global process, (i.e. preparation), was assessed by varying a foreperiod or warning interval (WI) in a two choice matching reaction time task. The measure of global attention in this task was improvement in RT compared to a condition with no WI. The second component, selective or focused attention was assessed by presenting one of a pair of stimuli to be matched ahead of the other, thus preselecting the dimension to which one must attend. Selective attention was measured by improvements in accuracy as well as RT. Previous findings indicated that alertness and selectivity were separable and could occur together without interference.

In this investigation choice RT tasks used simple shapes to be judged as "same or "different" with a warning signal preceding the 2 shapes as a global attentional cue and one shape preceding the other as a selective attentional cue. Speed and accuracy of response was measured.

Both young and elderly controls demonstrated global and selective attention, as well as the ability to perform these components simultaneously. DAT patients were relatively intact on tasks that assessed each process independently, but were impaired on tasks that assessed attentional processes simultaneously. Measures associated with selective attentional processes (i.e.accuracy) were more impaired than those associated with global processes (i.e. RT). These results suggest that 1) global and selective attentional processes are relatively preserved in DAT and elderly controls, but 2) simultaneous use of these processes is impaired in DAT relative to controls.

## Acknowledgments

> "One can discover much as a relatively passive observer, but there is much more that can be discovered only through action. And social action, like simple locomotion, informs us about ourselves as well as about the world with which we are engaged."
>
> (Neisser, 1976)

With this important thought in mind I want to thank the many people who helped me through this long learning experience. First, my thanks go to Dr. Wilma Rosen who encouraged me through out my training. Taking very seriously the mentorship role, she gave generously of her time and energy to provide me with direction and moral support. She encouraged me to work independently, to experience each step of the research process, to examine and question critically, and to integrate past knowledge with new information. She shared with me her own experiences, both personal and professional. I am grateful for her friendship and guidance which has allowed me to know more about myself as a professional and as a person.

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My parents, family and friends have been patiently supportive and I want them to know how much they have meant to me. I hope they will now celebrate with me, both in person and spirit.

To Victor

....for all the love, encouragement and respect we shared and the possibilities it represents.

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# INTRODUCTION

Although memory functions in the elderly and in persons with age-related diseases, such as dementia of the Alzheimer type (DAT), have been examined, little work has been done to investigate systematically suspected attention deficits in these populations. Theories of memory assume that attentional processes direct the organism toward an event in order for memory to occur. While changes in memory function could be due to many different mechanisms, attentional processes may be impaired in age related diseases and are deserving of further investigation.

Several models of attention exist, many utilize a broadly defined concept of attention (Deutch & Deutch, 1963; Neisser, 1967; Norman, 1968; Welford, 1981). These models may have some commonalities which are best discovered by an examination of the tasks used to assess attention. Such an examination indicates that the concept of alerting or orienting mechanisms may overlap with the notion of arousal or preparedness (Posner & Rothbart, 1982). Others describe a different phenomenon known as "selective" or "focussed" attention (Neisser, 1967; Norman, 1968). This work begins with a review of these different components of attention, and findings on age-related changes in attention will be discussed. Several models of attention will be reviewed. A model by Posner & Bois (1970) is presented in detail because (1) it makes an attempt to integrate both the preparatory and selective aspects of attention and (2) it provides a framework within which the specific questions raised by the limited work on age changes in attention can be examined. This model was then be used to examine attention in a group of patients with Alzheimer's disease.

COMPONENTS OF ATTENTION

For the purpose of this review, attention is divided into two components: (1) an alerting phase, also known as arousal, and (2) a selective or focussing phase. These were chosen because they appear to reflect aspects of many models and provide a way of organizing the differences and similarities of features of attentional processes described by different investigators.

I. Arousal and the Preparatory Signal

Neisser described the first component as a "preattentive" mechanism (Neisser, 1967). He suggested that "preattentive" preliminary operations must take place before focal attention can operate. These operations are global and they serve to separate each stimulus "in its entirety, as a potential framework for the subsequent and more detailed analyses of attention" (p. 89). In addition, Neisser suggested that the preattentive mechanisms are automatic. Much cognitive activity of daily life is preattentive. For example, orienting movements of head and eyes are controlled automatically by this mechanism. Under some circumstances, such as in highly familiar situations, it is possible for the preattentive process to elicit responses directly.

Posner and Rothbart (1982) suggested that orienting is a behavior that can be used to measure arousal. When an organism orients, it directs its energies to ready itself for further input. This ability of an organism to ready itself is dealt with in the concept of "set." Set refers to the development or maintenance of expectation that further input is imminent. It is a type of activation or preparedness that is similar to Neisser's "preattention" in that it is global and provides no specific information about the stimulus. The typical experimental procedure used to study set is a simple reaction time task using a warning or preparatory signal. Reductions in reaction time (RT) serve as evidence for and as a quantitative measure of the effects of this mechanism. Since no intervening activity (such as decision making or response selection) occurs between warning signal and response, it is assumed that the change in RT is due to the degree of "set" or preparedness established by the warning interval (WI). Consistent findings summarized and reviewed by Gibson (1941) include: 1) a preparatory interval of uniform length improves simple reaction time and with repeated trials the RT will be almost instantaneous, 2) warning intervals of variable length slow reaction time, and 3) with variable WIs, the greater the difference between succeeding intervals the larger the RT.

The degree of set is often assessed by varying the length of the warning interval. An inverted U-shaped function exists between reaction time and warning interval length in which optimum RT performance occurs at a given interval with slower RT at both shorter and longer intervals. The optimum warning interval ranges from .5 to 2 seconds in duration and varies somewhat with the actual task. Brief WIs have been examined and improvement in RT increases up to 1000 msec (Bertelson, 1967). Studies using WIs between 1 and 3 seconds have yielded mixed findings. Some authors found that RT decreases (compared to a "no warning condition") with WIs increasing in length up to 2 sec (Rodnick & Shakow, 1940), while two separate studies reported increases in RT with WIs ranging from .5 to 8 sec (Klemmer, 1956) and .5 to 3.5 sec (Karlin, 1959). Increases in RT are a consistent finding as the WI becomes even longer and have been reported at WIs between 3 and 15 sec (McAdam, Knot & Rebert, 1969; Lovelace, 1973).

Set has also been studied in relation to age. Several findings have been consistently reported. The preparatory interval affects the RT in elderly much the same as it does in the young; i.e., regular intervals reduce RT, irregular intervals increase RT (Botwinick & Brinley, 1962) and the same U-shaped function occurs with increasing length of the warning interval (Lovelace & Sanford, 1974).

There are differences however between old and young subjects. First, as might be expected, RT is always greater in older subjects. Second, the slowing at short intervals is more pronounced among older subjects than among younger (Welford, 1981). In examining the disproportionate slowing with short warning intervals, Welford (1981) suggested that the slowing with age may be due to the greater tendency to monitor, or to remain engaged with the information from the warning interval. That is, elderly subjects may not be able to adequately switch from monitoring to responding. This idea is supported by the finding that elderly subjects have faster RTs when the warning stimulus is turned off than when it remains on until the onset of the critical stimulus (Botwinick, Brinley & Robbins, 1958). With this procedure the subject does not remain engaged in the warning stimulus.

Third, in some cases longer than optimal preparatory intervals are associated with increased slowing in old relative to young subjects. In keeping with the idea of slowed switching, it is possible to postulate that at the long warning intervals the elderly subject again becomes involved in the signal, losing the ability to disengage from the warning signal and switch to responding. An alternate explanation is that the warning properties are only sustained for a limited period of time and fatigue or habituation is greater in the elderly (Welford, 1984).

One severe limitation of these studies is that no single study has used one task to examine the range of warning intervals, from very short to very long, to compare performance in different age groups. Thus, it is impossible to determine if the effects are due to the separate tasks used or represent an actual age-related change in RT performance.

## II. Selective Attention

A second type of attention is focused or selective attention. This aspect is often measured by giving some amount of information which limits or focuses ones search for relevant target features. Neisser (1967) described focal attention as the "making of a more sophisticated analysis of chosen objects." He explained that focal attention does not occur automatically. Only those details of the input which have been actively preselected receive attention. Neither the details of the environment chosen for analysis nor the encoded stimulus is inevitable. At this stage of attention meaning or significance is attributed to the stimulus. In fact, Neisser described this as a constructive, cognitive process determined by the organism.

Others have defined attention in much the same way as Neisser although they have been less concerned with separating selective from global processes. Selective attention appears to be what Norman (1968) described in his model of attention and memory: attention is the process which extracts special features from the sensory signal. Here, attention is described as an automatic process which does the initial analyzing of sensory inputs. This analysis is based on "pertinence", a pre-set weighting, that attributes significance to certain features of an input. This operates much like Neisser's "focal attention." That is, these pre-set weightings can be viewed as information which directs the analysis of certain aspects of the stimulus. Like Neisser, Norman suggests that the establishment of pertinence is a cognitive process not a sensory one. However, while much of Norman's pertinence appears to be similar to Neisser's focal attention, some features overlap with the preattentive processes. For example, while setting pertinence is a cognitive process, attention itself, is viewed as an automatic process with a linear progression of operations. That is, an input is automatically encoded with no need to direct cognitive resources. The encoding is the inevitable result of a set of transducers.

Norman's view may be the result of the two types of attentional processes working together. The automatic nature of the process resembles the preattentive preparation function while the feature detection is the selective or focal function. The idea that there is a linear progression in operations might be the result of these two operations occurring in sequence or in a partially overlapping order.

Other theorists also describe a weighting which is similar to pertinence proposed by Norman. Deutch & Deutch (1963) described a model in which a weighting system referred to as the level of "importance", works simultaneously with the arousal system. In this model the "importance" or weighting and the arousal are not independent, implying that input with "more importance" can raise arousal level. Preparation is the result of excitation from the analysis that is initiated by the physical presence of the stimulus. This model has two limitations. It suggests signal analysis occurs prior to attention which is an awkward concept since attention is usually considered the first stage of all other analytic processes. In addition, the proposed interrelation of the two aspects of attention does not permit any conclusions about the differential nature of the two types of processes.

In general all of these models of the organization of attention do not include hypotheses to be empirically validated. Rather they are the result of the synthesis of a range of experimental and observational evidence. Thus, assessment of the adequacy of the models is difficult. Moreover, these models have not been applied to the elderly.

Attention in the elderly has usually been examined by looking at performance in a single task and without regard to any overall model of intact attentional processes. One approach to examining selective aspects of attention in the elderly has been to use tasks that introduce distractibility. These studies examined the effect of disruption of selective attention by either introducing ambiguity about distinctive features or by simultaneously presenting distracting stimuli.

One example of this approach is the work of Farkas and Hoyer (1980). In their task, cards with both target figures and distractors on them, were sorted into two groups according to the presence or absence of a target figure, and sorting time was measured. Two distractor conditions were run: (1) an easy condition with distractor that were very different (i.e.contrasting) in comparison to target stimuli, and (2) a difficult condition with distractors that were similar to target stimuli. As expected, elderly subjects were slower than young subjects in all conditions and similar distractors were associated with more slowing than contrasting ones. This slowing in elders was minimized when the position of the target figure on the card was consistent from card to card and was maximal when the position was varied. These authors concluded that there are age changes in the ability to select critical features from the stimulus set.

There are several methodological issues that make it difficult to interpret these results. Card sorting demands extensive motor movement, and since elderly subjects are known to be slower this measure will maximize age differences. Even if sort time is expressed as a proportion of a baseline condition, maximizing the base rate of a single group will confound the group by task differences.

Another concern is that the distractor conditions may represent different levels of difficulty in the two age groups. Task difficulty was examined by Posner and Bois (1971) in a RT paradigm designed to examine selective attention. They reported increased RT with more complex tasks. These results are described in detail in the next section, but point to the importance of matching task demands when making comparisons among groups.

Card sort time may reflect more than one attentional process. Arousal systems as well as selective attention may be involved since subjects need first to know where to attend. They need to examine the entire stimulus field in a global way before they begin the selective analysis to make the right choice. The global contribution of the process may change if the task demands change. This is particularly true in the condition which varied the position of the target stimuli because the variation disrupts the subject's ability to establish set regarding the location of the critical stimuli.

Rabbitt (1965) has also suggested that elderly subjects have difficulty ignoring irrelevant information, particularly when complex discriminations are involved. He required subjects to sort cards which contained target and distractor letters and found that the sort time in elderly compared to young was differentially increased with an increase in the number of distractors. This finding was interpreted as evidence that elderly subjects have difficulty disengaging from irrelevant stimuli thereby reducing the efficiency of this measure of selective attention. While card sort time may maximize age differences due to its large motor component, as described above, it does appear that selective attention in the elderly is particularly susceptible to distractions. What is unknown however is whether selective attention is intact in older subjects when no distraction is present. When given information ahead of time, can they use it to maximize their response? The following model of attention provides a means for examination of (1) the intactness of two attentional components (a preparatory component and a selective attentional component) and, (2) the interactions of these components.

A Two Component Model of Attention

Two aspects of attention have been identified by using different types of tasks. Posner & Bois (1971) proposed a model of attention which was detailed in later work (Posner, 1986). This model, which proposes two components of attention, and organizes many of the features of attentional systems described above, was used to examine attention in the present study.

According to this model there is a nonspecific attentional component that prepares the subject to make a response to a critical stimulus. When events such as warning signals, preceding the critical stimulus occur in a predictable fashion they maximize the individual's ability to respond rapidly. The signal provides the occasion for the subject to orient internal systems toward responding. This feature corresponds to the concept of set, and is referred to as "preparation" by Posner. In his model, Posner uses the term "phasic" to describe the time limited nature of the effects of the warning. That is, increasing the length of the warning speeds responding, but only to a certain point. The alertness can not be sustained beyond a certain period of time. While the preparation provided by warning signals speeds performance, it has no effect on accuracy because it does not provide specific information about stimulus features. In addition and for the same reason, preparation should have an equal effect in both "same" and "different" responses in choice RT tasks.

The second component in this model is a selective attentional process that is referred to as "encoding". Like other concepts of selective attention, encoding is described as the process that occurs when information is provided about the specific details of a stimulus. In this model encoding focuses one's attention on specific features of an oncoming event and therefore should improve any response measure that is sensitive to specific stimulus information. Posner describes encoding as a process of "pathway activation" in which an event alerts the subject to a specific stimulus detail by activating a neural substrate. Exposure to specific stimulus features permits a build-up of information and thus a greater encoding improvement. Encoding should improve accuracy since it directs a subject towards features of a stimulus that are needed to analyze and respond. Speed is also used as a measure of selective attention in tasks that require choice or stimulus analysis and selection such as card sorting and choice RT. In such tasks encoding should increase speed and disruption of encoding should slow performance. The type of response might be differentially sensitive to improvement from the encoding process. For example in a matching task when the first event (or stimulus) is used to make a decision about the following stimulus, a matching response should show more improvement than a nonmatching response because, according to the model, there has been priming for the specific features of the match but not for the features of a different, nonmatching stimulus.

According to Posner's model these two components act on different levels of processing and therefore should be able to be demonstrated independently and simultaneously. A single task was used to identify both components and to determine if they were separable. In a two choice matching reaction time task subjects were required to view two letters to determine if they were the same or different and the reaction time (RT) to respond was measured. Three types of categories for matching were examined. In some cases subjects were instructed to look for a physical match (i.e. identical letters). In other cases, a naming match was required and upper and lower case letters were used. A third type was a vowel to vowel or consonant to consonant match. Each type of match required encoding the stimulus at a different level.

In the first part of the task, blocks of trials with a fixed warning interval were presented. Although the absolute reaction time differed greatly in each type of match, peak performance in each case was reached at the same warning interval of 500 msec. Plotting the warning interval by reaction time provided the "preparation function", which was approximately the same shape in each matching task. (See Appendix A).

To examine encoding, subjects were presented with the first letter for a brief interval (i.e. an inter-stimulus interval) prior to the second letter. The trials were preceded by the optimal warning interval of 500 msec so that maximum preparation was possible. Decreases in reaction time were attributed to the encoding permitted by the early presentation of the first letter. Posner found that the "encoding function" was also the same across the different types of matching tasks, and peak performance was achieved at an inter-stimulus interval of 500 msec, although the absolute value of the RT was smaller than in the warning function. (See Appendix A).

The response function, which Posner called "both" (because it reflected contributions from both preparation and encoding) was obtained by varying the inter-stimulus interval (ISI) in the absence of a warning interval. This function is called "both" because the first letter acts both as a warning and as an encoding stimulus. Here again the relative shape of the function was the same across all three tasks and it appears steeper than both the preparation the and the encoding function.

This model predicted that the improvement in the both condition would reflect contributions from preparation and encoding. To examine this prediction difference scores were generated at each interval in each condition. In the preparation condition, the RT at each warning interval was subtracted from the the baseline, which is the RT with no warning. These difference scores were calculated in the encoding condition using the RT at the optimal warning interval (WI=500 msec) as the baseline. In the "both" condition the baseline RT was the same as in the preparation condition (no WI, no ISI). These difference scores, reported in msecs are presented in Appendix B. In general the difference score (which is a reflection of improvement) in the both condition was almost exactly the sum of that obtained separately from encoding and preparation. Posner suggests that the additive nature of improvement indicates that the two processes, preparation and encoding, can proceed in parallel without interference.

Task demands, however, played a systematic role in these findings. In general, longer RTs were found with more difficult tasks. In the preparation condition, the absolute value of the RTs increased in a complex vowel consonant matching task up to 50msec over a simple physical letter matching task. These differences were even greater in the encoding condition.

The shape of the preparation function was only mildly affected by the task demands, with the most difficult matching tasks increasing the variability and the effect size. The encoding function was dramatically affected with the largest RT changes in the difficult task. Finally, in the "both" condition some loss of additivity was found with the complex matching task. Specifically, the improvement from the interstimulus interval was less than the sum of the improvement from the preparation and the encoding conditions, although it was greater than either condition alone.

These findings have possible implications for the study of attention in aging. What has been found repeatedly in the literature on aging is that age associated decrements appear when tasks accentuate multiple processing demands and switching from one activity to another (Rabbit, 1965, Farkas & Hoyer, 1980; Welford, 1984). If, indeed, the preparation function and the selective function can be separated, then the question can be asked, do these functions look the same in old subjects as they do in young? Additionally, by using the "both" condition it can be determined if the two processes continue to proceed in parallel with age.

DEMENTIA OF THE ALZHEIMER TYPE (DAT)

Alzheimer's dementia has become a growing topic of interest in scientific research. This is undoubtedly due in part to prevalence estimates ranging from 2.5 to 5% of the population over 65 years of age in European and U.S. studies. Estimates of the number of people with mild to moderate dementia in the U.S. is approximately 1.5 million, and this group is largely a community dwelling population (Terry and Katzman, 1983).

Clinical criteria have been established for the diagnosis of Alzheimer's Disease with particular emphasis on features of importance for research protocols. These guidelines indicate that dementia, established clinically, should be documented by a quantitative mental status examination. Deficits in two or more areas of cognition should be established with neuropsychological testing. Other impairments include interference with activities of daily living. Progressive worsening of cognitive function is also expected. These deficits should occur in the absence of disturbances of consciousness or other psychiatric, metabolic, neurologic or nutritional disturbances. Confirmation of the diagnosis requires pathological verification at autopsy of neurofibrillary tangles and neuritic plaques in the cerebral cortex (McKhann, Drachman, Folstein, Katzman, Price & Sadlan, 1984).

Perhaps the most frequently described deficit is memory impairment and much as been written on the specificity and extent of this deficit. It is not the only cognitive loss, however, and other areas of deficit include language, reasoning ability, and visuospatial functions (Rosen, 1983). Patterns of neuropsychological deficits in DAT may vary depending on premorbid functioning, but several general statements can be made. First, the deficits always include memory impairment and cognitive deficit in at least one other domain. Second, the deficits in DAT patients become more pronounced, relative to controls, as any given task gets more difficult. Also, as the illness progresses, the deficit increases (Rosen, 1983).

There is a range of the degree of impairment in DAT which has been assessed in many ways. Overall measurements of cognitive deficits have been assessed using the Information-Memory-Concentration (IMC) portion of the Blessed Dementia Scale. Since the the presence and extent of neuropathology has been correlated with this measure it a frequently used instrument (Blessed, Tomlinson and Roth 1968). Other instruments have been used to measure severity of the illness or stages of the disease and they often include items described in this original test or depend on correlations with the Blessed procedure for validation.

ATTENTION IN DAT

It would not be surprising to find that attention is a function that is impaired in DAT because attentional deficits can accompany any cerebral insult and has been reported in both diffuse (Lezak, 1983) and focal brain injury (Costa, 1962). It is more surprising that so little information is available on the nature of attentional processes in DAT. Given the two component model described above one would expect that selective attention, which is the more cognitively loaded component would be particularly susceptible to disruption in DAT. Deficits in digit span and repetition have been reported as evidence of attentional disruption in these patients (Vitaliano, Breen, Albert, Russo & Prinz, 1984). However, performance on these tasks can be affected by many cognitive processes and it is unclear why these authors attribute deficits on such tasks to attention.

Several authors have reported reaction time studies in dementia patients. Not surprisingly, most studies demonstrated that DAT patients exhibited slower reaction time when compared with normal elderly subjects (Davous and Lamour, 1985; Ferris, Crook, Sathananthan and Gershon, 1976; Giaquinto, 1985; Pirozzolo, Christensen, Ogle, Hansch and Thompson, 1981; Tecce, Cattanach, Boehner-Davis, Branconnier and Cole, 1983). In addition, DAT patients were found to be as slow as a group of parkinsonian patients who are known to have specific motor impairments and bradyphrenia in a simple reaction time task (Mayeux, Stern, Sano, and Cote, 1986), and slower than depressed patients in a four choice reaction time task (Pirozzolo, Mahurin, Loring, Appel and Maletta, 1985). In the latter study, however, RT to correct responses included the time to make wrong choices prior to making the correct choice. Since dementia patients made more errors this method maximizes DAT reaction time scores . Errors are often used as a measure of task difficulty and therefore it seems that the RT in this task was being measured under different levels of task difficulty in the two groups. Task difficulty can have an effect on attentional levels which will be described later.

In a study comparing a group of dementia patients of non-specific etiology to age-matched controls and young controls, dementia patients were slower on both simple and choice reaction time tasks (Ferris et al., 1976). This study used long (two second) warning intervals, which are associated with decrements in RT of normal elderly as described earlier. The dementia patients did dramatically worse on the disjunctive tasks, which supports the idea of more impairment in selective attention than in preparation.

The present study was constructed to permit an examination of specific attentional components of preparation and encoding. The model and methods described by Posner (1986) were used to examine the separability and interaction of these components in patients with DAT.

## STUDY DESIGN TO EXAMINE ATTENTION

The task described by Posner and Bois (1971) has several useful features for assessing the separate components of attention. It was the purpose of this study to use a similar procedure to examine these components in the elderly and in DAT patients. This task was designed to examine the specific model of attention proposed by these authors and described above. In review, the following features of the model were examined here. The first aspect to be examined is the demonstration of two distinct attentional components, preparation and encoding. Preparation is the nonspecific attentional process to be demonstrated by showing performance improvements in the presence of a warning interval. According to the model, these performance improvements would be reflected in measures of speed of response. Encoding is the selective or focused attentional component that is demonstrated in the presence of a stimulus that provides specific information to be used in responding to a stimulus. When encoding is maximized, performance improvements would be reflected in measures of both speed and accuracy. The second feature of the model to be examined was the proposed additivity of the two attentional components. It was postulated that under appropriate task conditions permitting the two components to occur simultaneously, the improvement should equal the arithmetic sum of the improvement seen with each process alone. This additivity was reflected in measures of speed since each component of the model was originally tested under conditions of maximum accuracy.

In a choice RT matching task manipulation of WI length was used to assess preparation; manipulation of ISI length, in the presence of an optimal WI, was used to assess encoding. The "both" condition, to be referred to as the "combination" condition in this study, used the ISI alone to assess the additivity of the two processes. In order to examine the DAT and elderly groups, features of the procedure differed from that originally described and a review of previous findings suggested that methodological changes can yield different results. A group of young subjects was included to insure that these changes still permitted observation of the separate attentional components and the additivity of the two. Several methodological issues were addressed with pilot studies conducted to assess changes from the original procedure and to determine specific task parameters.

METHODOLOGICAL ISSUES

One very important issue is the nature of the dependent variable itself. The dependent variable can be affected by many things, including subject and task variables that are not of primary interest. Ideally, the measure should be equally sensitive in all groups to be compared. It is well established that RT increases with age under most conditions, although minimization of the motor component of the response and reduction of response choices can reduce these age effects (Welford, 1984). For these reasons the present study used a two choice RT task with a simple response (button press). Since the literature indicates that the DAT group is slower than normal elderly, one analysis included normalization procedures to equate individual contributions to group effects. This permitted the examination of the effect of the WIs and the ISIs without depending on the absolute value of the RT. With these manipulations the assumption was made that the RT measure is equally sensitive in each group over the entire range of conditions.

Task difficulty, as described earlier, affected the shape of the encoding function and was associated with a loss of additivity in the "both" condition. This limitation is particularly important if a task is to be used to examine group differences in these processes. Any given task must represent the same level of difficulty for each group to insure that the same processes are being tapped in a similar way for all subjects. DAT patients might be expected to have difficulty with the types of categorical matches used in Posner's original task. The present study used only four different simple shapes as stimuli for matching tasks. Since this procedural difference might have resulted in a task so simple that the control population would demonstrate a ceiling effect, pilot work was undertaken to insure that this simplified task could be performed by the DAT patients and still be used to delineate the two attentional components and additivity in the young controls.

Another concern addressed in pilot studies was determining the optimal warning interval. This must be established for the encoding condition in which the optimal WI is presented with varying ISI's. It was possible that the length of the WI yielding the shortest RT would be different in each group. Furthermore, the impact of less than optimal (either shorter or longer) intervals might also differ in each group. Again, when comparing group differences it is important to insure that the groups are equally sensitive to the features of the paradigm.

Measures of accuracy must also be dealt with in choice RT tasks. In the Posner paradigm practice and prior exposure were given to maximize accuracy and RT was measured with accuracy held constant and presumably high. According to the model it would be postulated that preparation (i.e. a warning interval) might improve speed but should not affect accuracy. Encoding however might very well be expected to improve accuracy if the performance was not already at a ceiling level. While the original studies using this procedure do not describe accuracy changes (Posner and Boies, 1971) later work suggests a role for measures of accuracy. It is suggested that in the encoding condition the first letter permits a build up of information that will determine the correct response when the second letter appears. This build-up is observed in an increase in accuracy when the interstimulus interval goes from zero to 300 msec (Posner, 1986). However accuracy changes are difficult to observe when a high degree of practice precedes the experimental trials. The present study used only minimal training, and accuracy will be used as a measure of task difficulty, which permitted an assessment of the equivalence of task demands among the three groups.

PILOT STUDY

The purpose of the pilot study was (1) to assess the ability of normal elderly and DAT subjects to perform this modified task reliably; (2) to insure that this version would permit replication of the separate attentional components in young controls; and (3) to determine the WI that would provide maximum preparation to be used in the encoding condition.

The features analyzed for replication were (1) preparation and encoding functions and (2) the relative additivity of these functions under the combination condition. To determine if the elderly and DAT subjects could perform the task reliably, it was necessary to demonstrate that they could understand the instructions, make the discrimination and consistently make the appropriate response.

Methods

Subjects: The pilot study used three groups of subjects. A young control group (n=5; aged 22-27 years) was selected to examine the model using this simplified task. All had at least 16 years of education and were right handed.

An elderly control group (n=5; aged 65-72 years) consisted of volunteer subjects who were attending a senior center. All were community dwelling, reported no neurological or psychiatric history and denied visual difficulty.

A group of DAT patients (n=8; aged 61-70 years), consisted of individuals who were hospitalized for participation in a drug trial. The admission diagnosis of dementia of the Alzheimer type was made by a neurologist though documentation of the diagnosis was not done in the pilot study. Since the severity of illness might be an important issue in subject selection for the proposed study, the IMC portion of the Blessed Dementia Scale (Blessed, Tomlinson & Roth, 1968) was administered to all patients in this group. Performance on this test however, did not determine subject selection in the pilot study.

Procedure: All subjects were administered a 2 choice matching RT task using 4 shapes as stimuli presented on a computer monitor. These shapes are shown in Appendix 2. Subjects were asked to determine if 2 shapes were the same or different by pressing an appropriate key and they were encouraged to respond as rapidly as possible. RT to respond was measured after a brief training period. Trials were run in blocks of 24 for each interval of each condition. A baseline condition was run in which 2 shapes appeared immediately. To assess the preparation function RT trials were preceded by warning intervals of 125, 250, 500, 750 and 1000 msec. The combination condition was assessed with ISIs of the same length in the absence of a WI. A warning interval of 750 msec was used to assess the encoding condition in all three groups. In addition, both control groups were run in an encoding condition that used a WI of 250 msec.

Results

For the group of young subjects Figure 1 shows the preparatory and encoding functions and the function resulting in the combination condition. The preparatory function is the result of varying the length of the WI. The "encoding " function is the result of varying the length of the ISI in the presence of the optimal WI. The combination condition results from varying the length of ISI in the absence of a separate WI. In this condition, the first stimulus acts both as a warning signal and as an encoding signal. As in Posner's work, mean optimal performance appeared to be at the 500 msec interval in both the encoding and preparation curves, with little change from this optimal performance at intervals of up to 750 msec. However, examination of the individual data suggested that optimal performance occurred at the 250 msec interval in 4 of the 5 subjects.

To demonstrate relative additivity of the functions the improvement in each condition was calculated. Group mean RT was used in these calculation since that was the procedure used in the original study. The improvement in RT, which equals the appropriate baseline RT minus the RT at each interval is presented in Table 1. In the preparatory and combination conditions the baseline RT is measured at the zero/zero (WI/ISI) condition (i.e. immediate presentation of the stimuli). In the encoding condition the baseline RT is taken from the condition with the WI associated with optimal RT (WI=500msec) and zero ISI. Thus while the encoding condition is associated with the lowest absolute value for RT, the improvement due to encoding can be less than that due to preparation since a lower baseline is used to calculate the improvement scores in the encoding condition. The mean improvement across all intervals with the combination condition represents 94% of the improvement in the preparation plus the encoding condition.

A group of 5 elderly subjects was also run. All understood and completed the task. One subject had two blocks of trials with an error rate greater than 25%. This may have been due to distractions in the testing area. Data has been summarized for these subjects. Figure 2 illustrates the three conditions. Since it appears that the peak in the preparatory function occurred at 750 msec, this WI interval was used to assess the encoding condition. The 750 msec interval was also the point of the optimum performance for the encoding condition. The improvement in each condition is displayed in Table 2. The mean improvement across all intervals with the combination condition represents 100% of the improvement in the preparation plus encoding condition.

Eight DAT patients were also tested. Four patients, who were unable to comprehend the task, obtained error scores ranging from 14-17 on Blessed IMC. The remaining three subjects scored between 5 and 10 on this test. These results suggest that mild to moderately impaired DAT patients could engage in the task, while more severely impaired patients could not. One additional subject was eliminated because of diagnostic uncertainty.

Figure 3 presents the three conditions in this group. With this small group it appears there is no systematic improvement in the preparatory or encoding condition though there does appear to be some in the "both" condition. This would suggest that the two functions are not readily separable in these subjects, although the group is too small to draw any conclusions. However, this pilot study indicates that the task can be reliably performed by DAT patients who demonstrated a mild degree of impairment on a global mental status examination.

In summary it appeared that the DAT and control elderly could performed this task and that the preparation, encoding and combination conditions were preserved in the young and old control groups in this simplified procedure. It was decided to use DAT patients with IMC scores below 14 to insure that participants would be able to comprehend the task. Maximum performance was reached with WIs of 250 msec in the young group but there was no decrement at longer intervals. For the elderly 750 msec appeared to be the optimal WI and it was decided to run all three groups at this WI so that comparisons could be made under the same procedures. The young and old control groups were to be run at a second encoding condition using 250 msec WI. This permitted additional comparisons between the control groups.

Since the preparation function was not demonstrated in the DAT group, an additional task using simple RT was added to determine if preparation could be elicited with a less demanding procedure. As described earlier simple RT has been used to assess the global attentional component which is captured in the preparation function. A warning interval is used to establish expectancy and the RT measure is free of any decision making time which may be present in a choice RT paradigm. If decision making processes are so disrupted in the DAT patient, they may interfere with the patient's ability to utilize the warning signal in the choice RT task. The simple RT task may permit observation of global attentional process. This task was administered to all three groups and varied the two dimensions of set typically used to assess global measures of attention; consistency and length of WI.

HYPOTHESES

The literature reviewed above leads to several predictions concerning performance on RT tasks independent of any model of attention. Based on these findings, the following, non-model related hypotheses are proposed:

1. Normal elderly will have slower reaction times than young controls in all conditions.
2. DAT patients will be slower than normal elderly in all conditions.

The literature, though sparse, and the pilot data indicate that elderly subjects demonstrate improvements in RT with longer warning intervals. This suggests that global attentional processes assessed in the preparation function are intact. In addition, while elderly subjects may be more readily distracted, they do demonstrate systematic improvement in RT with lengthening inter-stimulus intervals, indicating the intactness of selective attentional processes assessed in the encoding function. Since the model of attention examined here postulates that these two processes occur in parallel and there is evidence that the two components are intact, it is predicted that improvement of the two components should be additive. Therefore the following model based hypotheses are proposed:

3. Normal elderly will demonstrate systematic preparation and encoding functions similar to that of young subjects although peak performance may be reached at longer intervals.
4. Normal elderly will demonstrate additivity of improvement of the encoding and preparation trials in the combination condition.

The few DAT subjects did not show systematic improvement with lengthening ISI and WI. This limited data suggested that these groups are different from normal elderly although it was not possible to predict the exact nature of this difference.

# METHODS

## Subjects

### Young Control Group

This group consisted of 10 volunteers ranging in age from 20 to 30 years old. Exclusion criteria for this group were:

a) history of neurological or psychiatric illness reported upon questioning by examiner

b) poor visual acuity determined by an inability to distinguish test stimuli on a video screen

c) less than high school education.

### Elderly Control Group

This group consisted of 12 community dwelling volunteers ranging in age from 55 to 75 years old. Exclusion criteria for this group were:

a) history of neurological or psychiatric illness reported upon questioning by examiner

b) poor visual acuity determined by an inability to distinguish test stimuli on a video screen.

### Alzheimer's Disease group

This group consisted of 9 patients with a clinical diagnosis of dementia of the Alzheimer type.

Criteria for dementia were those outlined in the diagnosis of primary degenerative dementia in the Third Edition of the Diagnostic and Statistical Manual of Mental Disorders (1980).

A review of clinical laboratory results and medical history was conducted to eliminate other sources of dementia. Based on the recommendations for establishing diagnosis for research purposes (McKhann et al, 1984) the following exclusionary criteria were used:

a) evidence of alternative causes of dementia by laboratory studies (computed tomography, electroencephalography, CSF examination, complete blood count, serum B12 level, and measures of thyroid, renal, hepatic, and pulmonary function)

b) evidence of cerebrovascular disease to exclude multi-infarct dementia (Rosen et al, 1980)

c) presence of focal neurological deficit

d) history of other neurological or psychiatric illness.

Mental Status Screen

The IMC portion of the Blessed Dementia test (Blessed, Tomlinson and Roth, 1968) was administered to elderly volunteers and DAT patients. In accord with previous reports elderly subjects who made more than 4 errors on this test were excluded from the control group.

DAT patients with error scores greater than 14 were excluded since it was demonstrated in pilot data that individuals with scores in this range were unable to perform the test.

Demographic information for the three groups is presented in Appendix C.

Apparatus

All tasks used the same apparatus. Experiments were run on a Commodore 64 computer. Displays were presented on a color television with a 13 inch diagonal screen. Responses were made by pressing a designated key on the right side of the Commodore 64 keyboard. Trial data was collected on an audio cassette and transferred to disk for storage after each subject was run.

Procedures

A simple reaction time task with blocked and random trials and a two choice reaction time task were administered. The data collected were reaction time (RT) to key press and number of errors in the choice RT task. Only the RT to correct responses was recorded in the choice task.

1. Simple Reaction Time Task

A circle with a radius of 2 cm was used as the stimulus for the simple reaction time task. The circle was black in color, presented on a blue background. It appeared in the center of the screen and remained on until a response was made. A warning interval was marked by the onset of the word "Ready" appearing in the center of the screen prior to the presentation of the stimulus; It disappeared when the stimulus came on.

Two conditions were run. The order was randomized within groups.

A. Blocked Condition

Two blocks of 24 consecutive trials with the same warning intervals (125 msec or 750 msec) were used. The order of the blocks was counterbalanced.

B. Random Condition

In this condition the same 2 warning intervals were presented in quasi-random order. Two blocks of 24 trials were run providing 24 trials of each warning interval across the two blocks.

2. Choice Reaction Time

Four shapes were used as stimuli in the choice reaction time task. They were black in color and presented on a blue background. The stimuli were: 1) a square with sides = 2cm; (2) a circle with radius = 2cm; (3) an equilateral triangle with sides = 2 cm and resting on a base; and (4) an equilateral triangle with sides = 2 cm and resting on a vertex.

The two stimuli appeared side-by-side in the center of the screen and separated by 5 cm. Subjects were seated in front of the screen, which was positioned at eye level, and were instructed to place the thumb and forefinger of their right hand on two keys of the keyboard. The keys were positioned vertically (i.e. one above the other) and the bottom key used to make a "same" response while the top key to make a "different" response. Subjects determined if the two shapes were the "same" or "different" and pressed the appropriate key. They were encouraged to be accurate and to respond as quickly as possible.

Trials were run in blocks of 24. Half of the trials were matching shapes (same) while the other half were non-matching shapes (different). The reaction time to key press (RT) and accuracy was recorded. Two types of errors were possible: misses i.e. responding "different" to two identical stimuli, and false alarms, i.e. responding "same" to two different stimuli.

Subjects were pretrained on this task in two blocks of 24 trials without WI or ISI, in order to familiarize them with the stimuli and the procedure. In the second block the subject were encouraged to work as quickly as possible.

A. Preparation Condition

In this condition a warning interval (WI) was used. This interval is the period from onset of a warning signal to the appearance of the two stimuli. The warning signal consisted of the word "READY" printed in the center of the screen. It remained on during the warning interval and disappeared when the stimuli appeared. The warning intervals were 125, 250, 500, and 750 msec. A block of 24 trials was administered at each interval and intervals were randomly ordered within groups.

2. Encoding Condition

In this condition an interstimulus interval (ISI) was present along with an optimal warning interval. The interstimulus interval is the time from the onset of the first stimulus to the onset of the second stimulus. The intervals were 125, 150, 500, and 750 msec. Based on pilot data the optimal warning intervals appeared to be 250 msec for young controls and 750 msec for elderly subjects and DAT subjects. Old and young controls were tested at both intervals to insure covering the critical intervals. The DAT subjects were run only at the 750 msec interval.

3. Combination Condition (Preparation plus Encoding)

The third condition was the condition in which the first stimulus acts as both a warning and as a focusing on encoding stimulus. Thus only an ISI is used, and the ISI's were 125, 250, 500, 750 msec. Blocks of 24 trials were administered at each interval and intervals were randomly ordered.

The order of conditions was randomized within groups. Baseline performance for the preparation and combination conditions was determined in a condition with no warning interval and no inter-stimulus interval, i.e. 0 msec presentation. This condition was run at the beginning and end of the session. The average of these two blocks was used to determine baseline performance.

Since an examination of the data depends on the RT in correct trials, blocks with more than a 25% error rate (i.e. 7 errors or more) were repeated. Analysis of error data however was done on the first block of any condition even if the error rate was greater than 25%.

Data Analysis

(1) Reaction Time Data

a. Simple RT (Blocked and Random): For each subject the highest and lowest score in each block was eliminated and the mean for the remaining trials was calculated. In the random trials a mean for the entire two blocks was calculated after eliminating the extreme scores. Means for the 125 msec warning and the 750 msec warning were also calculated.

b. Choice RT: A mean reaction time for correct trials was calculated for each block after elimination of the highest and lowest scores for each subject. In addition, the mean reaction time for hits and correct rejections was calculated.

Repeated measures analysis of variance was used to examine all reaction time data to compare the 3 groups at each condition. In the simple RT task a three way analysis was used (i.e. groups by interval length by blocking condition) with interval length and blocking condition nested. In the choice RT task a two way analysis was used and the factors were group and interval length. This was carried out separately in each condition and for total RT, RT for hits and RT for correct rejections. Improvement over baseline was calculated for each interval of each condition using group mean data to assess additivity and to make comparisons to findings in the original Posner and Bois (1971) study.

(2) Error Analyses

Errors were recorded for each block of trials. The number of errors and ranks of error scores were examined. Nonparametric statistics were used to examine error data since the overall number of errors was low and the distribution of errors varied in skewness among the groups. Chi Square analysis of the frequency of errors was used to determine differences among the three groups. Since there is no post hoc procedure for examining the differences between specific groups with frequency data, a Mann Whitney U statistic was used to determine differences between groups when the Chi Square was significant. To examine differences among the three conditions within each group a Wilcoxon Matched Pairs signed ranks test was used and pairwise comparisons were made.

## RESULTS

### I SIMPLE RT TASK

The mean RT for each group and condition is shown in Table 4. An analysis of variance (ANOVA) was used to examine the simple RT with group, warning interval length and condition (blocked vs random) used in the analysis. Examination of the significant main effect for group [$F(2,28)=53.14; p<.0001$] using the Duncan Multiple Range test revealed that the DAT group had significantly longer RT than the Young Controls, but no other post-hoc comparisons were significant. There were significant main effects for interval length [$F(1,28)=40.26; p<.0001$], with longer warning intervals yielding shorter RT, and condition [$F(1,28)=30.09; p<.0001$], with blocked times yielding shorter RT than random times. No interactions were significant. These results suggest that the improvements in RT with the longer interval and in the blocked condition are similar among the three groups.

### II CHOICE RT TASK

The following analyses examined RT in preparatory, encoding and both conditions separately. An ANOVA was used to examine group and interval effects in each condition with post-hoc analyses using the Duncan Multiple Range test. This was done for total RT, RT for hits and RT for correct rejections. A repeated measures ANOVA was performed with each group separately to examine the effects of the interval, and comparisons among the intervals were done with the Duncan Multiple Range procedure.

A. Preparatory Condition

1. Total RT: Means and standard deviations for each group at each warning interval are shown in Table 5. An ANOVA revealed a

significant main effect for group [$F(2,28)=773.9; p<.0001$], and post hoc analysis revealed that the DAT group was significantly slower than both control groups, and the Control Elderly were significantly slower than the Control Young. There was also a significant main effect for interval length [$F(4,28)=3.0; p<.05$]. RT was significantly longer at the two shortest intervals of zero and 125 msec compared with the two longest intervals of 500 and 750 msec. Nonsignificant differences were found among the zero, 125, and 250 msec intervals and among the 250, 500, and 750 msec intervals. The group by interval length interaction was not significant [$F(8,28)=1.0; p=.41$].

2. RT for Hits: There was a significant main effect for group [$F(2,28)=570.76; p<.0001$] and interval length [$F(4,28)=3.61; p<.01$]. Post hoc analyses revealed the same pattern of significant differences among the 3 groups and among the intervals as found in the total RT results.

3. RT for Correct Rejections: The only significant main effect in this data was found with group [$F(2,28)=422.5; p<.00001$]. Post hoc analysis revealed that the DAT patients were slower than both control groups, and the Control Elderly were significantly slower than the Control Young. Interval length [$F(4,28)=1.4; p=.24$], and the group by interval length interaction [$F(8,28)<1$] were not significant.

4. RT for Each Group: A repeated measures ANOVA performed on each groups separately revealed no significant differences in any group at any interval using total RT, RT for hits, or RT for correct rejections.

Overall these results indicate that the RT was slower in the DAT group than in the controls and that the Control Elderly were slower than the Control Young. While there was an effect of interval length across all subjects the effect was not evident in any single group.

B. Encoding Condition (750msec WI plus ISI)

1. Total RT: Means and standard deviations for each group at each interstimulus interval are shown in Table 6. A significant main effect was found for group [$F(2,28)=331.0; p<.001$]. Post hoc analysis revealed that the DAT group had significantly longer RTs than the other two groups; the two control groups were not significantly different from each other. There was also a significant main effect for the length of interval [$F(4,28)=4.86; p<.01$]. The RT in the 750/zero interval was significantly longer than the other intervals; nonsignificant differences were found among all other intervals. The group by interval length interaction was not significant [$F(8,28)<1.0$].

2. RT for Hits: This data also yielded a significant effect for group [$F(2,28)=392.9; p<.0001$]. As with the total RT data the post hoc analysis demonstrated a significant difference between the DAT and the other 2 groups, which did not differ from each other. There was a significant main effect for interval length as well [$F(4,28)=7.37; p<.001$]. Post hoc analysis revealed significantly longer RTs in the 750/zero interval than in all other intervals. Nonsignificant differences were found among the 125, 250, an 500 msec intervals and among the 250, 500, and 750 msec intervals. The RT at the 125msec interval was significantly longer than at the 750msec interval.

3. RT for Correct Rejections: There was a significant main effect for group [$F(2,28)=225.7; p<.0001$] and the post hoc analysis revealed that the RT in the DAT group was significantly longer than in

the other two groups. The RT in the two control groups was not significantly different. There was a significant main effect for length of interval [$F(4,28)=2.54; p<.05$]. Nonsignificant differences were found among the zero, 125, and 500 msec intervals and among the 125,250, 500 and 750 msec intervals but the RT in the zero interval was significantly longer than in the 250 or 750 msec interval.

4. <u>RT for Each Group</u>: In the DAT group there were no significant differences among the intervals in the total RT [$F(4,32)=1.1; p=.38$], RT for hits [$F(4,32)=1.69; p=.18$] and RT for correct rejections [$F(4,32)<1$].

In the Control Elderly there was a significant difference among the intervals in the total RT [$F(4,44)=6.59; p<.001$] and the post hoc analysis revealed the RT at the zero interval was significantly longer than all other intervals but no other comparisons were significant. In this group there was also a significant difference in the RT for hits [$F(4,44)=6.04; p<.001$]. The RT in the zero interval was significantly longer than the RT in the 250, 500, and 750 msec interval and the RT in the 125 msec interval was significantly longer than the RT in the 750 msec interval. Nonsignificant differences were found between the zero and 125 msec interval; among the 125, 250, and 500 msec interval and among the 250 500 and 750 msec interval. There was also a significant difference among the intervals in this group in the RT for correct rejections [$F(4,11)=2.64; p<.05$]. The RT at the zero interval was significantly longer than the RT at the 250, 500 and 750 msec interval. All other comparisons were nonsignificant.

In the Control Young group there was a significant difference among the intervals in the total RT [$F(4,9)=4.53; p<.005$] and the post hoc analysis revealed the RT at the zero interval was significantly longer than all other intervals, but no other comparisons were significant. In this group there was also a significant difference in the RT for hits [$F(4,9)=6.2; p<.001$]. The RT in the zero interval was significantly longer than the RT in the 250, 500, and 750 msec interval and the RT in the 125 msec interval was significantly longer than the RT in the 250 msec interval. All other comparisons were nonsignificant. There was no significant difference among the intervals in this group in the RT for correct rejections [$F(4,9)=2.35; p=.07$].

In summary in this condition the DAT group was slower than both control groups, which did not differ from each other. In addition the DAT group did not demonstrate a reduction in RT with interval length while both control groups did.

C. Encoding Condition (250msec WI plus ISI)

1. Total RT: This condition was run in the two control groups only. Means and standard deviations for the groups at each ISI are shown in Table 7. The Control Young had a significantly faster RT than the Control Elderly [$F(1,20)=359.9; p<.0001$]. There was also a significant main effect for interval length [$F(4,20)=14.1; p=.0001$]. Post hoc analysis revealed that the RT in the 250/zero interval was significantly longer than in the other intervals; nonsignificant differences were found among all other intervals. The group x interval length interaction was not significant [$F(4,20)=1.95; p>.1$].

2. RT for Hits: There was also a significant main effect for group in this data [$F(1,20)=278.7; p<.0001$] with the Control Young performing faster than the Control Elderly. There was a significant effect for interval length [$F(4,80)=10.9; p<.0001$]. The RT at the 250/zero interval was significantly longer than at all other intervals. The RT at the 250/125 interval was significantly longer than the RT at the 250/500 interval and the RT at the 250/250 interval which was the fastest, was significantly shorter than the 250/125 and 250/750 intervals. No other comparisons were significant. The group x interval length interaction was not significant [$F(4,80)=1.8; p>.1$].

3. RT for Correct Rejections: There was a significant main effect for group [$F(1,20)=325.8; p<.0001$] with the RT for the young group significantly faster than the RT for the elderly. There was also a significant effect for interval length [$F(4,20)=14.1; p<.0001$]. Post hoc analysis revealed that the RT at the 250/zero interval was significantly longer than the RT at any other interval. No other comparisons were significant.

4. RT within Each Group: In the Control Elderly there was a significant difference in total RT among the intervals [$F(4,44)=12.12; p<.001$]. There was also a significant difference in the RT for hits [$F(4,44)=9.05; p<.001$]. There was a significant difference among the intervals for the RT for correct rejections [$F(4,44)=9.93; p<.001$].

In the control young there was a significant difference in the total RT among the intervals [$F(4,36)=3.64; p<.05$]. There was a significant difference among the intervals for the RT for correct rejections [$F(4,36)=2.77; p<.05$]. There was a significant difference in the RT for correct rejections [$F(4,36)=4.9; p<.001$].

Overall this condition appears to yield the best performance in the control groups with the fastest RT at the 250/250msec interval. In addition, unlike the 750 msec Encoding condition, the Control Young are faster than the Control Elderly.

D. Combination Condition (interstimulus interval only)

1. Total RT: Means and standard deviations for each group at each interstimulus interval are shown in Table 8. A significant main effect for group [$F(2,28)=277.53; p<.0001$] was revealed. Post hoc analysis revealed significantly longer RT in the DAT group than in both control groups, but the Control Elderly were not significantly slower than the Control Young. Interval length was also significant in this condition [$F(4,28)=6.31; p<.0001$]. RT at the zero ISI was significantly longer than at all other ISI values, but no other comparisons were significant. The group x interval length interaction was also significant [$F(8,28)=3.01; p<.005$]. To examine this interaction, predicted values for each group at each interval length were generated based on mean time and group effects, and compared to observed values. The observed and predicted mean RTs and the difference between them are presented in Table 9. Examination of these values indicated that differences at the 125 and 250 msec interval in the DAT group were larger than all other values. Since the standard error for this group is five times greater than the control groups the effect was explored by examining the interval length within each group separately because such large violations of homogeneity of variance did not permit between group comparisons.

2. RT for Hits: These results parallel those found with total RT in that there were significant main effects for group [$F(2,28)=251.5$; $p<.0001$], and interval [$F(4,28)=7.21$; $p<.0001$], and a significant group by interval length interaction [$F(8,28)=3.74$; $p<.001$). The post hoc analysis indicated that the DAT group was significantly slower than both control groups, which did not differ from each other, and the RT at the zero ISI was significantly longer than at all other intervals. Mean difference scores were generated as described above and are shown in Table 10.

3. RT for Correct Rejections: There were significant main effects for group [$F(2,28)=188.9$; $p<.0001$], and interval length [$F(4,28)=3.1$; $p<.01$], and a significant group x interval length interaction [$F(8,28)=2.33$; $p<.05$]. The DAT group was significantly different from the 2 control groups, which did not differ from each, other and the RT for the zero ISI was significantly higher than at all other intervals. As previously described, mean difference scores were generated and are shown in Table 11. The interaction is examined below using within group analysis because of the large difference in standard error among the groups.

4. RT within Each Group: In the DAT group there was a significant difference among the intervals in total RT [$F(4,32)=3.5$;$p<.05$]. The RT at the zero interval was significantly longer than all other intervals; no other comparisons were significant. This effect was also found in the RT for hits [$F(4,32)=4.0$;$p<.01$]. The RT in the zero interval was significantly longer than in the 500 or 750 msec interval. No other comparisons were significant. In the RT for Correct Rejections the overall F approached, but did not reach significance [$F(4,32)=2.5$;$p=.065$].

In the Control Elderly the ANOVA for the total RT in this group yielded a significant overall effect [$F(4,44)=4.18; p<.01$]. The post hoc analysis revealed that the RT in the zero interval was significantly longer than all other intervals. The ANOVA for the RT for hits was significant [$F(4,44)=6.6; p<.001$]. The post hoc test yielded a significant difference between zero and all other intervals. In addition the RT at the 750 msec interval was significantly longer than the RT at the two intermediate intervals, 250 msec and 500 msec. No other comparisons were significant. The RT for correct rejections was not significantly different at any ISI interval [$F(4,44)=1.2; p>.3$].

In the Control Young group there was no significant effects among intervals in this condition with total RT [$F(4,9)=1.3; p>.1$], RT for hits [$F(4,90)=1.2; p>.3$] and RT for correct rejections [$F(4,9)=1.1; p>.3$].

In this condition the DAT group was also slower than both controls, but the Control Elderly was no longer slower than the Control Young. There was a significant reduction in RT with longer intervals in the DAT group and the Control ELderly but not in the Control Young.

III ADDITIONAL COMPARISONS BETWEEN DAT AND CONTROL ELDERLY

Since there was little change in Control Young performance in any condition, additional analyses were conducted to examine differences between elderly subjects and DAT patients. Of particular interest was the possibility that RT improvements could be due to an interaction among group, interval length and type of response (hits vs correct rejections). To examine this, the following analyses were performed. In each condition difference scores, reflecting inprovement, were calculated by subtracting mean RT performance of the 125 and 250 msec intervals and of the 500 and 750 msec intervals from baseline RT values. This was done for RT for hits and correct rejections and a three way ANOVA was performed on data from each condition separately. The factors in these analysis were group (DAT vs Control Elderly), interval length (mean of 125 and 250 msec vs mean of 500 and 750 msec) and type of response (hits vs correct rejections). Data from the preparation condition and the encoding condition yielded no significant differences for any main effect or interaction. Data from the combination condition yielded a significant main effect only for group [$F(1,19)=10.0; p<.005$] and the DAT group had larger difference scores. The group x interval length x type interaction was significant [$F(1,57)=4.1; p<.05$]. No other interactions were significant. An examination of the means for these conditions (presented in Table 12) indicates that the interaction is due to the significantly smaller improvement in the short intervals with RT for hits in the DAT group. The improvement, presented graphically in Figure 4, is minimal at short intervals and greater at the longer intervals. A review of the absolute RT value in this condition in Table 8 indicates that the RT for hits is greater than the RT for correct rejections at the short intervals for the DAT group, which is an unusual pattern. The baseline for correct rejections is lower which contributes to the larger difference scores with this type of response. However the absolute value of RT is also lower in the correct rejections data than the hits. Since RT at all other ISIs is higher this result seems to be a local finding and not represent a systematic effect.

IV <u>ADDITIVITY OF IMPROVEMENT</u>

In order to compare the present results with those of Posner and Bois (1971), the absolute value of the improvement in RT (in msec) was calculated at each interval using group mean data. The analysis was done with total RT data only. Improvement in preparation function was calculated by subtracting the RT at each interval from the RT in the baseline condition (i.e.zero WI/zero ISI). Improvement in the combination condition was calculated by subtracting the RT at each ISI interval from the same baseline condition. For the encoding (750 msec WI plus ISI) condition the improvement was calculated by subtracting the RT at each ISI from the RT at 750msec WI. The results are presented in Table 13.

V ERROR ANALYSIS

For each condition the errors in each of the 4 interval blocks were summed for each subject. For each group the mean number of errors in each condition and the total of the three conditions were calculated and is shown in Table 14. The three groups were compared using the Kruskal-Wallis test, which yielded significant Chi squares as follows: for total errors ($x^2$=6.52;$p<.05$); for errors in the preparation condition ($x^2$=9.16;$p<.01$); for errors in the combination condition ($x^2$=5.81;$p<.05$). There was no significant difference among the groups in errors in the encoding condition ($x^2$=4.52;$p>.1$).

To examine significant differences between specific groups the Mann-Whitney U statistic was used on the ranked error scores. Compared to the Control Elderly, the DAT group made significantly more total errors (U=22.5;$p<.05$), errors in the preparation condition (U=18;$p<.05$), and errors in the both condition (U=23;$p<.05$). Compared to the Control Young, the DAT group made significantly more total errors (U=21.5;$p<.05$) and errors in the both condition (U=20.5;$p<.05$). There was no significant difference between these two groups in errors in the preparation condition or the encoding condition. There was no significant difference in errors between the old and young control groups in any condition.

To determine if there was a significant difference in difficulty (i.e. more errors) among the three conditions for each group a Wilcoxon Matched Pairs signed ranks test was used. In the DAT group there were significantly less errors in the encoding condition than in the both condition ($Z=2.03; p<.05$) and than in the preparation condition although the difference did not reach significance ($Z=1.89; p=.06$). There were no significant differences in errors among the three conditions in both the control groups.

Overall the error analysis suggests that the task was most difficult (i.e. more errors) for the DAT group and this difficulty was most evident in the Combination condition. The control groups were equally accurate in all conditions, while the DAT group did significantly better in the encoding condition.

VI <u>T-SCORE ANALYSIS</u>

To examine individual differences within condition the following transformation procedure was used. For each subject 13 scores (zero, 4 WI, 4 ISI and 4 ISI plus 750msec WI)were transformed to Z-Scores. These Z-scores were then transformed to T-scores. This subject-based normalization procedure permitted an examination of individual behavior uninfluenced by offsets in their means and standard deviation. In this way each subjects RT made an equal contribution to mean T-score values and both order and effect size of each RT is conserved. The T-scores for the RT, plotted against the interval length are shown for each group in Figures 5 thru 7. Analysis of variance of the T-scores provided a comparison of the three groups at each interval of each condition. A significant effect was found only in the Combination condition, at an

ISI of 750 msec [$F(2,28)=5.0$; $p<.01$]. Post hoc analysis with the Duncan Multiple Range test revealed that the DAT group had significantly lower T-scores than the control groups, which were not different from each other.

T-score summary variables for each condition were calculated for each subject as follows: Preparation mean was the mean of the T-scores for the 4 WI; Combination mean was the mean of the T-scores for the 4 ISI; Encoding mean was the mean of the T-scores for the 4 ISI plus 750msec WI. Group means of these summary variables are shown in Table 15. Pairwise comparisons of these variables were examined within each group using t-tests to determine if there were improvements in RT due to conditions. In the DAT group compared to the preparation mean, the both mean ($t=3.1$;$p<.01$) and the encoding mean ($t=3.2$;$p<.01$) were significantly less (i.e.faster RT), but there was no significant difference between the both mean and the encoding mean ($t<1$;ns).

In the control elderly,compared to the preparation mean the both mean ($t=2.24$;$p<.05$) and the encoding mean ($t=9.7$;$p<.001$) were significantly less. In addition the the encoding mean was less than the both mean ($t=2.03$;$p<.05$).

In the control young compared to the preparation mean the encoding mean was less ($t=3.46$;$p<.01$), but the both mean was not significantly different. The encoding mean was significantly less than the both mean ($t=2.46$;$p<.05$).

Attempts were made to determine if the order in which the intervals were delivered had an effect on RT. To this end each set of 4 T-scores within a condition was correlated with the order in which they were delivered. Practice effects (negative slopes) ranged up to one standard deviation unit and fatigue effects(positive slopes) ranged up to .4

standard deviation units. A one way ANOVA, used to compare the slopes among groups, yielded no significant difference [$F(2,28)=2.04; p=.14$]. The variation was random not being assignable to any subject, group or condition.

Attempts were made to look at the effect of the order of presentation of conditions on RT by examining T-score summary variables. Nonsignificant trends were found indicating that RT in conditions presented later were .2 standard deviation units faster. These effects were not distinguishable between groups.

# DISCUSSION

## OVERVIEW

This study was designed to examine attention in aging and DAT using a model taken from the cognitive psychology literature. This model which proposed two distinctive attentional processes that were independent and additive, was used to make predictions about the performance of normal elderly and DAT patients. This section begins with assessment of the predictions about these processes in the groups.

In addition to those predictions based on the model there were two hypotheses concerning the dependent measure, RT. These have important methodological consequences which will be discussed. The usefulness of cognitive models for understanding clinical populations will be reviewed with an emphasis on the underlying assumptions of such approaches. The present work will provide an illustration of the advantages and limitations of using model based tasks to examine cognitive changes accompanying aging and disease processes.

Finally the value of delineating attentional processes in DAT will be reviewed. Important issues include the potential in basic research, contributions to diagnosis and usefulness as a tool for assessing treatments.

## THE MODEL

The model of attention used in this study delineated two processes, Preparation and Encoding. A major feature of the model was the additivity of the processes. These aspects are discussed below with emphasis on the hypothesis concerning aging and DAT.

1.Preparation

Preparation refers to an attentional process that is global in nature. It is nonspecific and is comparable to an alerting phenomenon as described in the Introduction. In the preparation condition the RT was significantly reduced by the length of the WI as predicted by the Posner model. While only the shortest and longest WIs were statistically different, the graphs of the T-score data suggest a steady decline in RT with lengthening WI in all three groups. The absence of significant differences in RT at any interval when each group was examined separately may be due to the variability in the RT among subjects or to the relatively small number of subjects.

The size of the preparation effect in the choice paradigm is unclear, and it is difficult to assess. In the original model, the size of the effect was measured in msecs of improvement in RT and ranged from 50 to 120 msec in the simplest match. The effect of preparation was equal to the effect of encoding when this simple letter matching task was used. The mean improvement in RT in the two control groups in the current study was about 25 msec which is smaller than that reported by Posner. Since the size of the improvement increased with the difficulty of the task in Posner's study, one explanation for the smaller effect in the present work might be that this task with only four different stimuli was easier than the letter matching task described by Posner. In addition, the improvement is based on the change from a zero WI condition which, in the present study, inadvertently may have had preparation properties. For example the presentation rate, organized in blocks of trials, may have created a warning of sorts. To control for this phenomenon a random rate of presentation might have been used.

The simple RT task was added in order to assess the same type of global attention as that measured by the preparation condition, but in the absence of any demand to make a decision. The decrease in simple RT with increased length of WI was consistent with the choice RT results. In addition the improvement in RT in the blocked presentation compared to the random presentation is further evidence of generalized attentional processes since blocking permits the development of expectancy, a dimension of set previously described.

It is striking though that the effect of blocking, while evident in the DAT patients, is smaller than in either of the control groups. In addition the standard deviation is larger in the blocked condition than in the random condition for the DAT group, which would not be expected in a condition that was supposed to maximize set or expectancy. In the control groups, the blocked condition reduced RT and the standard deviation was smaller, as would be predicted. It may be that the DAT patients require more trials to establish expectancy. The fact that there was an improvement in RT in this condition suggests that set can be established though it is diminished. Perhaps with more practice the variability would decrease and the reduction in RT would increase.

The aspects of attention assessed by blocking were of a global nature and were considered automatic. The minimal effect of blocking in DAT raises questions about the automatic nature of these processes in this group. Posner commented that automaticity requires that a process occurs without intention and without producing interference with other ongoing activities. In other words these processes are not capacity limited. It may be that the effect of blocking is reflective of the patients' inability to perform this type of attention at a non-intentional level. That is, it may require more capacity than in normals. There may be a deficit in the ability to relegate this expectancy to an automatic process. Such an explanation would indicate that Posner's prediction of global and selective mechanisms proceeding in parallel might not be obtained in this population, which is discussed in the section on the Combination condition.

It is possible that the benefit of the warning is more evident in the simple task due to reduced variability of RT when the decision making time is not included in the RT measure. This will be discussed further in the section on encoding and the utility of the model.

In both tasks RT was significantly slower in the DAT group than in the control groups, which is consistent with studies reviewed earlier. However manipulation of the specific task demands thought to impact on global attention yield a pattern of performance in DAT patients which parallels that seen in control elderly and even in control young. With this in mind it is hard to interpret the longer RT in the DAT group as evidence of disrupted attentional processes. Rather it appears that global attention is intact, although it may not be performed as efficiently by DAT patients as by controls.

2. Encoding

The Encoding condition was designed to assess selective attention by combining the WI that provides maximum global attention with a set of ISIs. Here, as in the Preparation condition, task parameters were manipulated for each subject in order to observe the encoding phenomena over a range of ISIs. In the Preparation condition, the optimal WI across all subjects (i.e. the interval at which the lowest RT was reached) was 500msec, which matches that reported by Posner (1971). In the two control groups the lowest group mean RT was found with a WI of 250 msec. However the RTs at these intervals were not statistically different from each other. In the present study all subjects were run at 750 msec WI for the Encoding condition based on the pilot data. An additional Encoding condition was run in the control groups, using a 250 msec WI and in retrospect it appears that this shorter interval might have been more appropriate for the DAT group as well.

There was a significant improvement in RT with lengthening ISI demonstrated in the analysis which pooled all subjects, as predicted by the model. When the groups were examined separately, this effect was seen in the Control Elderly and in the Control Young. Although the DAT group mean RT did improve (i.e. RT decreased with increasing ISI) there was no significant difference in RT among the intervals.

A comparison of the two Encoding conditions (i.e. 250msec WI and 750 msec WI) indicates greater improvement with the shorter warning. Since longer than optimal preparation times have been reported to cause a decrease in RT, it may be that the performance at the 750 msec WI did not provide the optimal condition for observing encoding in these groups.

The effect of encoding was also examined with the T-score summary variables (mean RT in the four intervals of the preparation, encoding and combination condition). In all three groups the encoding mean was significantly shorter than the preparation mean suggesting that the ISI was responsible for improvement beyond that provided by a WI. Since the 750msec WI exceeds the maximal warning for most cases it is reasonable to suggest that the ISI benefit is due to another process such as selective attention. This is evidence for the separability of these two attentional processes in all three groups.

Selective attention can also be assessed with measures of accuracy. There was no significant difference in errors among the groups in the encoding condition, which can be taken as evidence of equivalence of the effect of the process.

These findings support the hypothesis that the Control Elderly demonstrate systematic encoding functions similar to the Control Young. Both groups were equally accurate suggesting similar task difficulty for each and the similar pattern of improvement in RT with increasing ISI suggests the intactness of selective attention in the elderly.

It is more difficult to assess selective attention in the DAT group since there was no systematic improvement in RT with increasing ISI. However within group analysis of error scores revealed that the DAT group was more accurate in the Encoding condition than in the Preparation condition and the difference approached significance. The improvement in the Encoding condition, both in T-score summary variables and accuracy, over that seen in the preparation condition, indicates that some selective attentional processing is taking place. There is further evidence to support the notion of intact selective attention in the DAT group in the Combination condition.

3. Additivity of Attentional Processes

The Combination condition in which the ISI acts as both a warning stimulus and an encoding stimulus was designed to test the hypothesis that the two types of attention were additive. That is that the benefit of global and selective attentional processes as measured by RT should be cumulative. In this condition there was an improvement in RT with increasing ISI. In the young controls the group mean RT and the summary variables were always lower in the combination condition than in the preparation condition although the differences were not significant. In the original study Posner & Bois (1971) reported from 100 to 200 msec of improvement with the letter matching task, which represents the sum of the improvements seen in the encoding and preparation conditions. In the present study the maximum improvement in this condition was 34 msec which was reached at 500 msec ISI. This follows the pattern, described in the other conditions, of a smaller effect seen in the current work than reported in the original study. The improvement in RT seen at any interval of the combination condition was larger than the improvement seen at any interval of the preparation condition. However, the improvement in the combination condition was also less than in the encoding condition at every interval indicating that while the processes may demonstrate some accumulation, they were not 100% additive as Posner suggested. Again it is possible that the smaller set of stimuli and the baseline effect are responsible for the difference. Additionally, the reduced baseline effect described above, would provide increased improvement in the preparation and the combination conditions, while providing a relative reduction in the encoding improvement. The overall effect of this would be to make the combination condition more closely approximate additivity. Since the original authors do not report the absolute value of the reaction times it is not possible to determine the effect size in terms of a proportion of the baseline variables.

In the control elderly there was a significant reduction in RT through the 500 msec ISI. In addition the T-score summary variables indicated that the RT in the combination condition was significantly better than the RT in the preparation condition for the elderly subjects, suggesting that the improvement was greater than the improvement from the warning interval alone. The size of the improvement varied with the ISI and ranged from 34 to 71 msec with the largest improvement at the 250 msec interval. The improvement with ISI was also equal to or larger than the improvement seen in the encoding condition and was equal to the sum of the improvements from the preparation and encoding conditions at the 250 msec interval. These results are consistent with the hypothesis that the Control Elderly would demonstrate additivity of these two processes.

In the DAT group there was a significant improvement in RT with increasing ISI. In addition the T-score summary variables indicated that the RT in the combination condition was significantly lower than the RT in the preparation condition,indicating that encoding processes were responsible for some improvement. The maximum improvement was 213 msec which approximates that seen in the original model. However the absolute values of the RT in this group were almost twice that of the controls. The greatest improvement was seen at the 750 msec ISI which was longer than the best intervals for either of the controls. The improvement was equal to the sum of the improvements in the other 2 conditions at this interval. However in 3 of the 4 intervals of this condition the RT was lower than the RT in the encoding condition and the improvement was greater than the sum of the preparation and encoding conditions. In addition the T-scores at the longest interval of this condition were significantly lower than either of the control groups. It may be that the encoding condition of this model does not permit adequate assessment of encoding for the DAT group. The model assumes that the WI that precedes the ISI can be used to maximally prepare for the stimuli and that encoding will immediately follow with the onset of the ISI. If the subject cannot sequence these two processes, the benefit from the ISI may be confounded by the time lost in switching to the appropriate attentional activity.

In the combination condition only, the DAT group did not demonstrate the predicted pattern of longer RT for correct rejections than for hits at the short ISIs (i.e. 125 msec, and 250 msec). The prediction is based on the concept of pathway activation. Making a "same" response, (i.e. a hit) should have an advantage over making a "different" response, since the neural pathway is primed by the presentation of the first stimulus and would speed processing of a matching stimulus. In fact this pattern of performance (faster RT for hits than for correct rejections) is evident in all other conditions and groups. One explanation for this effect is that neural pathways may be compromised in the DAT group in such a way that the benefit of the priming is not evident at short intervals because, possibly, of slowed neural transmission. With longer ISIs the priming benefit in the matching condition becomes evident.

There was also an interaction in the improvement data in the combination condition. This interaction demonstrated a marked improvement in RT for hits at the longer intervals as compared to the shorter intervals. In fact the improvement in the RT for hits at the short intervals is less than for the correct rejections, a pattern which is different from the controls. The concept of slowed transmission that interferes with the priming effect is consistent with this findings as well.

The interaction did not occur in the preparation condition since this is the condition that effects only the global, nonselective aspects of attention. The mechanisms for improved RT in the preparation condition do not include neural priming and the disruption of transmission would not be expected to interfere with this attentional process.

The disruption might be expected in the encoding condition since improvement in this condition should be exclusively due to selective attentional processes. However, the pattern of shorter RT for hits than for correct rejections is intact here. Since this condition utilizes a maximum warning interval it may be that there is an interaction between the two types of attentional mechanisms, at least in this group. That is, in the combination condition, when both processes are taking place simultaneously there is disruption of the selective process in terms of this priming effect. Further support for disruption of selective attention in the combination condition is found in the larger error scores, which is discussed below.

Another explanation for the absence of maximum improvement in RT in the encoding condition in the DAT group may be related to an interaction between two types of improvement measures, accuracy and speed. There were significantly fewer errors in the encoding condition than in the combination condition in the DAT group, but there was no difference between the number of errors in the preparation condition and the combination condition. Since accuracy may reflect encoding, this slower RT in the encoding condition may be the result of a trade-off with time and conversely the speed in the both condition may reflect a loss of attention to the selective features which resulted in more errors.

PREDICTIONS CONCERNING RT

As hypothesized it was found that the DAT group was significantly slower than the Control Young and the Control Elderly in both simple and choice RT tasks. The Control Elderly however were significantly slower than the control young only in the preparation condition and the encoding condition which used the shorter (250 msec) warning interval. The elderly group was not significantly different from the control young in the simple RT task, nor in the combination condition and the (750 msec) encoding condition of the choice RT task. Several features of the task demands may account for the lack of difference between these two control groups. As described earlier minimizing the motor response and the number of response choices, which reflects the conditions of the simple RT task used in the present study, are known to reduce age related difference in RT. Features of the choice RT task that may have minimized the age related RT differences include its relatively low cognitive demand and the absence of any significant memory load. Evidence for the cognitive simplicity of the task is found in the low error rate, and the absence of any difference in accuracy between the two control groups suggests that the task difficulty was equivalent for them. The RT associated with the preparatory condition where differences were found, may reflect the greatest amount of cognitive activity compared to the other choice RT conditions since it includes time to focus on, select, and respond. This higher cognitive demand may be responsible for the significantly longer RT for the elderly compared to the young in this condition. Conversely the RT in the combination condition and the encoding condition may reflect less cognitive activity since they utilize an ISI during which selection and decision making might take place. This would be expected to reduce age related differences.

USEFULNESS OF THE MODEL TO TEST GROUP DIFFERENCES

This model was originally designed to differentiate and to assess attentional processes. In the present study it was used to examine these processes in a patient group and to compare them to an appropriate control group. Two issues that need to be addressed to determine if this model can be useful in measuring group differences concern 1)task demands, and 2) practice effects. The task demands must be comparable for the groups particularly in those dimensions which are not under scrutiny. Task difficulty was thought to be important since in Posner's work it affected the shape of the curves that represent the attentional functions and the additivity of the two functions. In his studies more difficult matches yielded longer RTs and less than additive improvements in the "both" condition.

The question of task difficulty can be addressed by measures of accuracy and speed. The overall low error rate in the present study might be taken as evidence of the comparability of task difficulty particularly between the control groups. However there are several reasons why accuracy measures may not completely define task comparability between the groups. First, this accuracy may represent a ceiling effect in controls and despite equally few errors one group might actually find the task more demanding. Second, since speed can be affected by task demands, group RT differences should also be examined. The Control Elderly were slower than the Control Young but only in the preparation condition which, in Posner's work, was not systematically effected by task demands. Taken together accuracy and RT data suggest that task difficulty was the same in the control groups. However, the DAT group was slower in all tasks and less accurate. Therefore, it is reasonable to assume that the task was more difficult for the DAT group.

Given the likelihood of uneven difficulty it is necessary to address whether this task permitted assessment of the same functions in each group. If the worst case was assumed in which there was a different level of difficulty for each group one would predict maximum additivity in the group that found the task easiest. Therefore the improvement in the Combination condition for the Control Young should have been the closest to the sum of the encoding and preparation improvements. This was not the case. In fact, there was no improvement in the Preparation condition and only minimal improvement in the combination condition in this group. Based on this it might be speculated that if a task is very easy there is inadequate opportunity to view the two types of attentional processes. It may be that the maximum benefit in these easy tasks comes from a WI shorter than 125msec which was not explored here. Also, the RT improvement in this group may have been so small that it could not be reliably measured.

The Control Elderly look very much like the subjects in the Posner model. There is more improvement in the Preparation condition in this group than in the Young Controls. In addition, this group demonstrated additivity, with greater improvement in the Combination condition than in either the Preparation or the Encoding condition. Many of the task demands were designed to accommodate the patient and age appropriate control groups and it appears that these key features were conserved in the present study at least for the comparison of these 2 groups. Comparisons of Control Young and Control Elderly may require more difficult tasks.

The size of the set of stimuli to match may have differential effects on the RT in the two control groups since there is evidence of this in sorting tasks (Rabbitt 1965). Increasing the set size may have slowed RT, providing more room for improvement which may be required to demonstrate additivity. While the set size was kept small to accommodate the DAT group, a larger set may have been more useful in comparing the young and old subjects. Since additivity was demonstrated in the Control Elderly it appears that this model might be useful in comparing these two groups but that the restrictions of the task demands may not permit a three-way comparison.

Another feature of the task is the assumption that the sequencing of intervals would lead to the sequencing of attentional processes. There is evidence that greater than optimal warnings lead to a reduction in performance. The ISI in the Combination condition acts as a warning interval as well as an encoding stimulus and it is assumed that the subject will automatically use this interval for encoding when in combination with the best WI. The lowest RTs were found in the encoding condition for the two control groups suggesting that this sequencing did occur. This was not the case in the DAT group perhaps because of a deficit in this sequencing. It may be that DAT patients become engaged in the warning stimulus and cannot switch attention to the encoding stimulus. In this case the additivity of the functions might be demonstrated but the model would not permit delineations of the separate types of attention in this group.

Finally the issue of practice effects should be addressed, since the original subjects used by Posner and Bois (1971) were highly trained individuals and data was collected only after 2 days of RT sessions had been completed. This procedure could be responsible for the more systematic RT functions seen in the earlier study, because subjects might become highly trained in the use of the WI and ISI. Since practice effects involve memory which is specifically compromised in DAT it was important to implement this procedure in a way which would not produce additional differences in competency levels among groups.

In the present study there was a much shorter training period in which subjects were not exposed to the warning intervals. This training was designed only to insure that the subjects understood the task and were able to make the discrimination. Since the two control groups did not differ in RT in 3 of the 4 conditions it would appear that the present practice procedure did not interfere with comparisons between these 2 groups. There was a consistent difference in RT between the DAT group and the Control Elderly in all of the choice RT conditions. While it is possible that even this minimal practice could contribute to this difference, there are several other factors, as described in the section on RT, which could contribute to this differential effect. In addition, the finding that the order of presentation of intervals did not differentially affect any group suggests that practice did not make a major contribution to the the DAT group effects.

The second type of issue in assessing the usefulness of the model concerns the dependent variables. In the present study two types of variables were used, RT and errors. The errors were used as an index of the level of difficulty within each group. The assumption made in the use of this measure is that equal error rates imply equal difficulty for the groups. The consequences of this assumption are reviewed above and it seems reasonable to conclude that this accuracy index was useful in equating the Control Elderly with the DAT group.

RT as a dependent variable is sensitive to many factors and is subject to a wide range of individual differences. The present study used a repeated measures design to reduce the effect of individual variation when making comparisons among intervals which was the key analysis for testing the attentional model. The analysis of RT data demonstrated an overall significant effect of interval in all conditions which may be taken as evidence of reproducing the model. To compare conditions and groups the T-score analyses were used. These analyses demonstrated distinct patterns of performance without depending on the absolute value of the RT to make the comparisons. Thus it would appear that the this type of transformation of RT data was particularly useful in distinguishing group differences. It provided a conservative estimate of effects which is desirable when groups are known to be very different.

Overall the model of attention examined here has several advantages. It organized attentional mechanisms and provided testable hypotheses about processes rather than specific performances. The advantage to this is that it takes into account individual variation by comparing performance under different conditions. This is particularly important since the disease probably increases variability of performance. The model approach depends on patterns of difference rather than on effect size.

APPLICATIONS OF THE MODEL

Cognitive models as opposed to task based experimentation offer several advantages to understanding Alzheimer's disease. If this progressive illness has an impact on specific stages of attention, the model should permit delineation of these deficits over time. In addition this model of attention should permit comparisons among groups with cognitive deficits. For example, dementia as well as attentional deficits have been documented in Parkinson's Disease although the correlation of these has not been specified. This group is particularly sensitive to timed task demands and a within subject design used by this model might be useful in examining attention in this patient group and comparing it to DAT patients.

Reports of changes in RT as well as changes in other attentional tasks with cholinergic agents suggest that this model of attention might also be useful in examining drug effects in DAT. It would provide a stable baseline and an examination of specific types of attention. Pharmacological systems which have been implicated in other illnesses might also be worth examining.

While this cognitive model is useful in understanding the specificity of attentional deficits it is not necessarily an adequate diagnostic tool. Several authors (Pirizzolo et al, 1981; Ferris et al, 1976) have suggested that RT will differentiate normal elderly and dementia patients, particularly in a choice paradigm. However it is not clear that their procedures are measuring attention. In fact, in the present study the absolute value of RT usually did differentiate between the groups. The greater discriminability with the more demanding task is further evidence that the cognitive load and not the attentional aspects are making the discrimination.

Historically, cognitive processes have been examined using group data with the assumptions and limitations of sampling probability underlying the ability to make predictions. It may appear that the assumptions of group samples are too great since they do not necessarily predict the individual's performance. The experiment itself is a sampling however and a subject's performance within that experiment may not predict performance of the same function in vivo. In fact it may not predict performance on the very same task at a different point in time. Yet the model permits ways to test the aspects of the process. These tests along with data from other types of studies are the basis for establishing the validity. The fact that the two types of attention are evident in this patient group which has clear evidence of other cognitive deficits suggests that attentional processes are specific and separable function rather than generalized capacities.

CONCLUSIONS

The present study used a two component model to examine attention in normal elderly and DAT patients using an RT task. The results suggest there is minimal disturbance in attentional processes in mildly impaired DAT patients. Attentional processes must be assessed under a defined range of task difficulty since conditions that are too simple or too complex will disturb the additive nature of attentional components.

It was predicted that RT would be slower in the Control Elderly than in the Control Young and that the DAT patients would be slower than the Control Elderly. This was found to be true in the choice RT tasks but in the simple RT task the only group difference was found between the DAT group (who were slower) and the Control Young. These RT differences were attributed to task demands and group variables rather than to attentional processes.

It was predicted that the Control Elderly would demonstrate both global attention in the preparation condition and selective attention in the encoding condition. This was found to be the case using the choice RT task. It was also predicted that this group would demonstrate additivity of the benefits of these two processes in the Combination condition. This was also found to be the case in 3 of the 4 intervals.

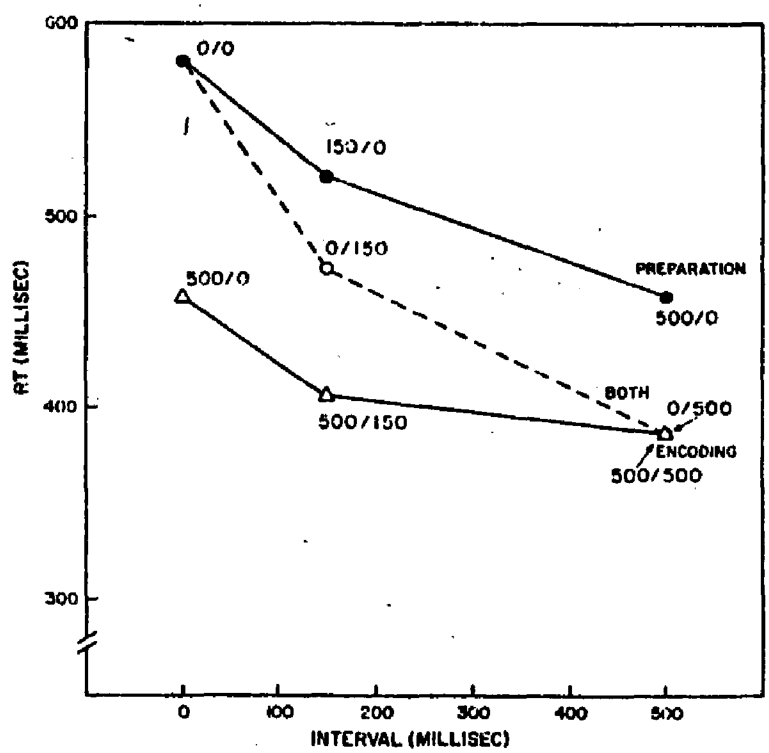
Additivity of the two types of attention was not adequately demonstrated with the choice RT task in the Control Young however and it was speculated that the task may have been too simple for observing the attentional processes in this group. Such lack of additivity with tasks that are too simple was not described by Posner. There was evidence for preparation (i.e.global attention) in the simple RT task in the Control Young in that they improved with longer and more regular WIs. There was significant improvement in the Control Young in the Encoding condition as well but the Combination condition yielded less improvement than the encoding condition alone at all 4 intervals.

The DAT group demonstrated global attention in both the simple and choice RT task. Selective attention was less dramatic in the Encoding condition than in the Combination condition and it was speculated that this was due to an inability of the DAT patients to benefit from the sequence of intervals. In this group the shortest RTs were found in the Combination condition. Only empirical evidence can determine the nature of attentional processes in more impaired DAT patients. However, given the importance of equating task difficulty in the present model it may procedures used here would not permit a comparison of patients with different levels of impairment. This model might be particularly useful in comparing equally impaired patients with different etiologies of dementia to examine the relative contribution and pattern of attentional deficits.

# APPENDIX A

## Components of Attention

## Physical Match Task

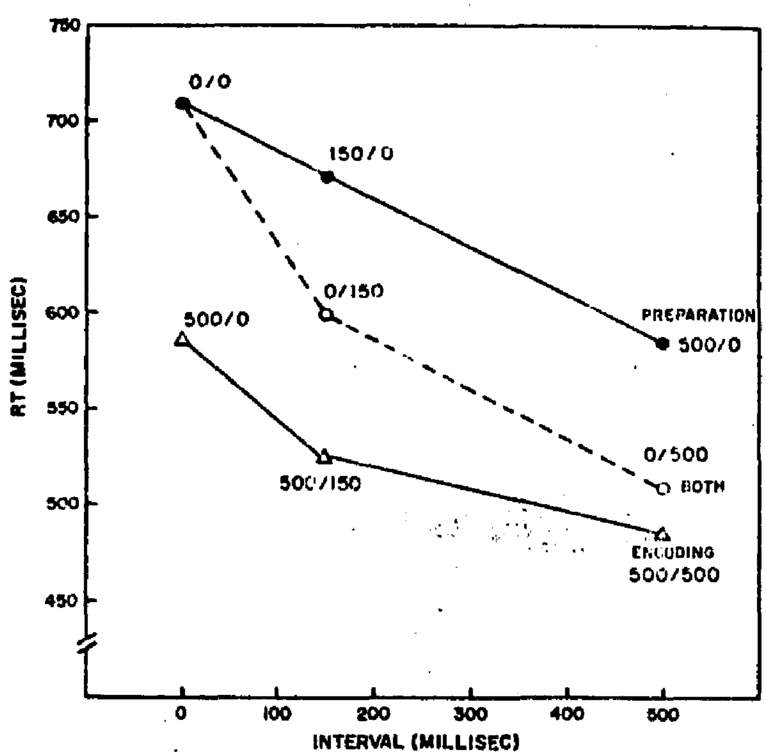



Preparation, encoding, and "both" functions for physical matching task. (Values of WI/ISI are shown for each point.)

APPENDIX A(continued)

Components of Attention

Name Match Task

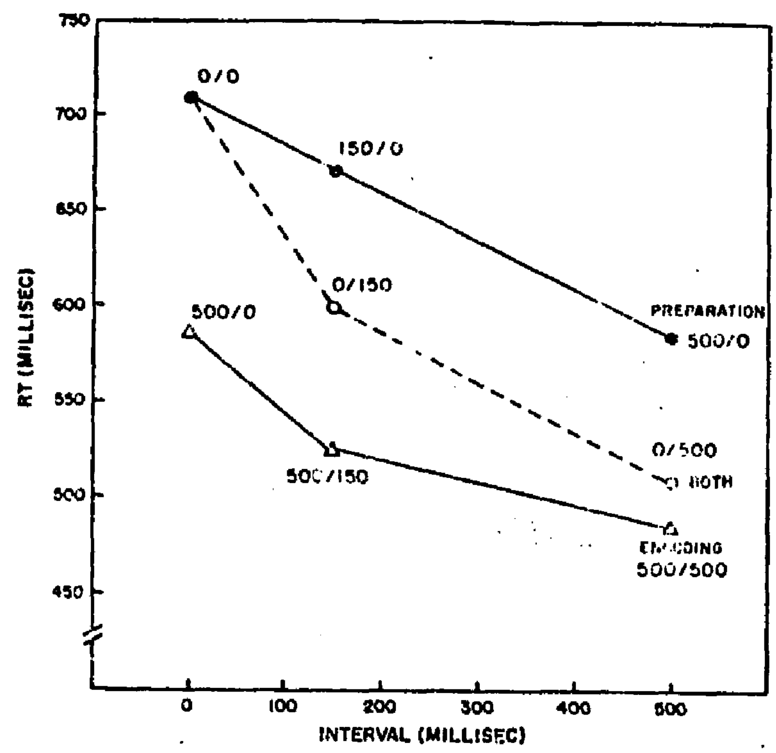



7. Preparation, encoding, and "both" functions for name matching task. (Values of WI/ISI are shown for each point.)

APPENDIX A (continued)

## Components of Attention

### Vowel-Consonent Match Task




Preparation, encoding, and "both" functions for name matching task. (Values of WI/ISI are shown for each point.)

# APPENDIX B

## Components of Attention: Amount of Improvement

Amount of Improvement in RT from Preparation, Encoding, and Both[a]

| | *Interval*[b] | |
|---|---|---|
| *Match* | *150* | *500* |
| Physical | | |
| Preparation | 58 | 122 |
| Encoding | 53 | 73 |
| Both | 101 | 195 |
| Name | | |
| Preparation | 42 | 127 |
| Encoding | 58 | 98 |
| Both | 111 | 201 |
| Vowel-Consonant | | |
| Preparation | 71 | 170 |
| Encoding | 124 | 150 |
| Both | 157 | 296 |

*Note:* Improvement is measured by subtracting RT at specified interval from RT at 0/0 for preparation and "both" function and 500/0 for encoding.

[a]From Posner and Boies (1971). Copyright 1971 by the American Psychological Association.

[b]In milliseconds.

# APPENDIX C

## Description of the Groups

| | DAT GROUP (N=10) | CONTROL ELDERLY (N=12) | CONTROL YOUNG (N=10) |
|---|---|---|---|
| AGE | 69 | 66 | 25 |
| (Range) | (56 to 82) | (54 to 76) | (22 to 30) |
| EDUCATION | 15.4 | 14.7 | 16.8 |
| BLESSED SCORES | 5 to 11 | 0 to 4 | - |

# TABLE 1

Improvement in Reaction Time

(in msec)

Young Subjects (n=5)

Interval Length in msec

| | 250 | 500 | 750 | 1000 |
|---|---|---|---|---|
| Preparation | 45 | 88 | 86 | 72 |
| Encoding | 67 | 100 | 96 | 103 |
| Both | 133 | 168 | 147 | 160 |

# TABLE 2

Improvement in Reaction Time

(in msec)

Normal Elderly (n=5)

| | Interval Length | | | |
|---|---|---|---|---|
| | 250 | 500 | 750 | 1000 |
| Preparation | 85 | 133 | 146 | 108 |
| Encoding | 56 | 78 | 105 | 58 |
| Both | 190 | 173 | 220 | 218 |

# TABLE 3

Improvement in Reaction Time

(in msec)

DAT Group (n=3)

Interval Length

| | 250 | 500 | 750 | 1000 |
|---|---|---|---|---|
| Preparation | 87 | 98 | 50 | 114 |
| Encoding | – | 31 | 52 | 42.5 |
| Both | 74 | 158 | 160 | 88 |

# TABLE 4

Simple Reaction Time Task
Mean RT in Msec
(± SD)

| | BLOCKED CONDITION 125msec | 750msec | Mean | RANDOM CONDITION 125msec | 750msec | Mean |
|---|---|---|---|---|---|---|
| GROUP | | | | | | |
| DAT | 398 ±178 | 348 ±142 | 373 ±155 | 416 ± 99 | 357 ± 71 | 386 ± 82 |
| CONTROL ELDERLY | 318 ± 70 | 259 ± 49 | 289 ± 56 | 376 ± 78 | 308 ± 84 | 342 ± 79 |
| CONTROL YOUNG | 255 ± 66 | 233 ± 47 | 244 ± 56 | 318 ± 65 | 257 ± 49 | 287 ± 56 |

## TABLE 5

### Mean Reaction Time in the Preparation Condition (in Msec)

#### Total RT (x±SD)

| GROUP | Zero | 125 msec | 250 msec | 500 msec | 750 msec |
|---|---|---|---|---|---|
| | WARNING INTERVAL LENGTH | | | | |
| DAT | 1025 ±308 | 997 ±320 | 964 ±275 | 928 ±275 | 939 ±251 |
| Control Elderly | 679 ±67 | 673 ±97 | 675 ±94 | 658 ±125 | 660 ±80 |
| Control Young | 512 ±48 | 521 ±64 | 492 ±58 | 496 ±42 | 498 ±52 |

#### RT For Hits (x±SD)

| GROUP | Zero | 125 msec | 250 msec | 500 msec | 750 msec |
|---|---|---|---|---|---|
| | WARNING INTERVAL LENGTH | | | | |
| DAT | 1000 ±313 | 997 ±365 | 920 ± 268 | 907 ±286 | 902 ±222 |
| Control Elderly | 666 ±69 | 664 ±106 | 655 ±97 | 646 ±137 | 643 ±92 |
| Control Young | 500 ±47 | 506 ±63 | 476 ±62 | 491 ±41 | 489 ±50 |

#### RT For Correct Rejections (x±SD)

| GROUP | Zero | 125 msec | 250 msec | 500 msec | 750 msec |
|---|---|---|---|---|---|
| | WARNING INTERVAL LENGTH | | | | |
| DAT | 1057 ±321 | 993 ±301 | 972 ±287 | 948 ±297 | 974 ±298 |
| Control Elderly | 670 ±69 | 661 ±96 | 687 ±98 | 667 ±119 | 659 ±76 |
| Control Young | 522 ±49 | 528 ±56 | 508 ±58 | 499 ±47 | 500 ±47 |

TABLE 6
Mean Reaction Time in the Encoding Condition (750msec Warning)
(in Msec)

Total RT (x±SD)

| GROUP | Zero | 125 msec | 250 msec | 500 msec | 750 msec |
|---|---|---|---|---|---|
| | INTERSTIMULUS INTERVAL LENGTH | | | | |
| DAT | 939 ±251 | 858 ±301 | 854 ±326 | 853 ±381 | 815 ±287 |
| Control Elderly | 660 ±81 | 617 ±90 | 596 ±74 | 601 ±100 | 590 ±91 |
| Control Young | 498 ±52 | 470 ±68 | 446 ±75 | 466 ±58 | 452 ±71 |

RT for Hits

| GROUP | Zero | 125 msec | 250 msec | 500 msec | 750 msec |
|---|---|---|---|---|---|
| | INTERSTIMULUS INTERVAL LENGTH | | | | |
| DAT | 902 ±222 | 830 ±245 | 815 ±282 | 815 ±334 | 780 ±266 |
| Control Elderly | 643 ±92 | 609 ±94 | 584 ±88 | 580 ±94 | 562 ±96 |
| Control Young | 489 ±50 | 479 ±77 | 429 ±77 | 454 ±68 | 452 ±86 |

RT for Correct Rejections

| GROUP | Zero | 125 msec | 250 msec | 500 msec | 750 msec |
|---|---|---|---|---|---|
| | INTERSTIMULUS INTERVAL LENGTH | | | | |
| DAT | 974 ±298 | 888 ±374 | 865 ±334 | 888 ±423 | 854 ±331 |
| Control Elderly | 659 ±76 | 625 ±88 | 606 ±72 | 620 ±109 | 615 ±92 |
| Control Young | 500 ±47 | 462 ±66 | 463 ±73 | 470 ±66 | 453 ±63 |

TABLE 7
Mean Reaction Time in the Encoding Condition (250msec Warning)
(in Msec)

Total RT (x±SD)

| GROUP | Zero | INTERSTIMULUS INTERVAL LENGTH 125 msec | 250 msec | 500 msec | 750 msec |
|---|---|---|---|---|---|
| Control Elderly | 675 ±94 | 600 ±93 | 567 ±76 | 570 ±87 | 595 ±72 |
| Control Young | 492 ±57 | 452 ±70 | 435 ±46 | 451 ±74 | 447 ±64 |

RT for Hits

| GROUP | Zero | INTERSTIMULUS INTERVAL LENGTH 125 msec | 250 msec | 500 msec | 750 msec |
|---|---|---|---|---|---|
| Control Elderly | 655 ±97 | 596 ±97 | 560 ±92 | 552 ±86 | 580 ±86 |
| Control Young | 476 ±62 | 452 ±72 | 421 ±48 | 438 ±76 | 458 ±80 |

RT for Correct Rejections

| GROUP | Zero | INTERSTIMULUS INTERVAL LENGTH 125 msec | 250 msec | 500 msec | 750 msec |
|---|---|---|---|---|---|
| Control Elderly | 687 ±98 | 602 ±92 | 573 ±68 | 595 ±91 | 606 ±64 |
| Control Young | 508 ±58 | 453 ±74 | 448 ±49 | 456 ±80 | 437 ±56 |

TABLE 8
Mean Reaction Time in the Combination Condition
(in Msec)

Total RT (x±SD)

| GROUP | Zero | 125 msec | 250 msec | 500 msec | 750 msec |
|---|---|---|---|---|---|
| | INTERSTIMULUS INTERVAL LENGTH | | | | |
| DAT | 1025 ±308 | 836 ±221 | 937 ±423 | 850 ±383 | 812 ±267 |
| Control Elderly | 679 ±67 | 638 ±93 | 608 ±80 | 617 ±78 | 645 ±93 |
| Control Young | 512 ±48 | 492 ±70 | 488 ±72 | 478 ±85 | 493 ±78 |

RT for Hits (x±SD)

| GROUP | Zero | 125 msec | 250 msec | 500 msec | 750 msec |
|---|---|---|---|---|---|
| | INTERSTIMULUS INTERVAL LENGTH | | | | |
| DAT | 1000 ±313 | 860 ±253 | 941 ±481 | 811 ±355 | 753 ±189 |
| Control Elderly | 666 ±69 | 622 ±91 | 588 ±80 | 592 ±78 | 630 ±95 |
| Control Young | 500 ±47 | 482 ±74 | 484 ±80 | 467 ±79 | 476 ±86 |

RT for Correct Rejections (x±SD)

| GROUP | Zero | 125 msec | 250 msec | 500 msec | 750 msec |
|---|---|---|---|---|---|
| | INTERSTIMULUS INTERVAL LENGTH | | | | |
| DAT | 1057 ±321 | 808 ±187 | 934 ±373 | 890 ±454 | 869 ±338 |
| Control Elderly | 670 ±69 | 656 ±101 | 628 ±84 | 634 ±82 | 658 ±98 |
| Control Young | 522 ±49 | 502 ±68 | 494 ±67 | 491 ±94 | 508 ±74 |

TABLE 9

Differences Between the Observed and Predicted RT

in the Combination Condition

Total RT Data

| GROUP | ISI LENGTH | N | SE | MEAN | PREDICTED MEAN | DIFFERENCE |
|---|---|---|---|---|---|---|
| DAT | ZERO | 9 | 0.1025 | 1.026 | 0.954 | 0.071 |
| | 125 msec | 9 | 0.0736 | 0.836 | 0.877 | -0.041 |
| | 250 msec | 9 | 0.1411 | 0.937 | 0.893 | 0.044 |
| | 500 msec | 9 | 0.1275 | 0.850 | 0.869 | -0.018 |
| | 750 msec | 9 | 0.0890 | 0.813 | 0.873 | -0.060 |
| CONTROL | ZERO | 12 | 0.0192 | 0.679 | 0.699 | -0.020 |
| ELDERLY | 125 msec | 12 | 0.0270 | 0.638 | 0.622 | 0.016 |
| | 250 msec | 12 | 0.0230 | 0.608 | 0.638 | -0.030 |
| | 500 msec | 12 | 0.0224 | 0.617 | 0.614 | 0.004 |
| | 750 msec | 12 | 0.0268 | 0.645 | 0.618 | 0.027 |
| CONTROL | ZERO | 10 | 0.0150 | 0.512 | 0.555 | -0.043 |
| YOUNG | 125 msec | 10 | 0.0220 | 0.492 | 0.477 | 0.015 |
| | 250 msec | 10 | 0.0228 | 0.488 | 0.494 | -0.005 |
| | 500 msec | 10 | 0.0269 | 0.478 | 0.469 | 0.009 |
| | 750 msec | 10 | 0.0246 | 0.493 | 0.473 | 0.020 |

TABLE 10

Differences Between the Observed and Predicted RT

in the Combination Condition

RT For Hits Data

| GROUP | ISI LENGTH | N | SE | MEAN | PREDICTED MEAN | DIFFERENCE |
|---|---|---|---|---|---|---|
| DAT | ZERO | 9 | 0.1044 | 1.000 | 0.935 | 0.065 |
| | 125 msec | 9 | 0.0843 | 0.860 | 0.871 | -0.011 |
| | 250 msec | 9 | 0.1605 | 0.941 | 0.882 | 0.059 |
| | 500 msec | 9 | 0.1184 | 0.812 | 0.840 | -0.029 |
| | 750 msec | 9 | 0.0629 | 0.753 | 0.841 | -0.088 |
| CONTROL | ZERO | 12 | 0.0199 | 0.666 | 0.681 | -0.015 |
| ELDERLY | 125 msec | 12 | 0.0262 | 0.622 | 0.617 | 0.004 |
| | 250 msec | 12 | 0.0230 | 0.588 | 0.628 | -0.040 |
| | 500 msec | 12 | 0.0224 | 0.592 | 0.587 | 0.005 |
| | 750 msec | 12 | 0.0274 | 0.630 | 0.587 | 0.042 |
| CONTROL | ZERO | 10 | 0.0149 | 0.501 | 0.543 | -0.043 |
| YOUNG | 125 msec | 10 | 0.0236 | 0.482 | 0.480 | 0.003 |
| | 250 msec | 10 | 0.0253 | 0.484 | 0.491 | -0.007 |
| | 500 msec | 10 | 0.0250 | 0.467 | 0.449 | 0.018 |
| | 750 msec | 10 | 0.0274 | 0.476 | 0.450 | 0.026 |

TABLE 11

Differences Between the Observed and Predicted RT

in the Combination Condition

RT FOR CORRECT REJECTIONS

| GROUP | ISI LENGTH | N | SE | MEAN | PREDICTED MEAN | DIFFERENCE |
|---|---|---|---|---|---|---|
| DAT | ZERO | 9 | 0.1071 | 1.057 | 0.968 | 0.088 |
| | 125 msec | 9 | 0.0623 | 0.809 | 0.885 | -0.076 |
| | 250 msec | 9 | 0.1243 | 0.934 | 0.907 | 0.027 |
| | 500 msec | 9 | 0.1512 | 0.891 | 0.896 | -0.006 |
| | 750 msec | 9 | 0.1126 | 0.869 | 0.905 | -0.036 |
| CONTROL | ZERO | 12 | 0.0199 | 0.671 | 0.706 | -0.036 |
| ELDERLY | 125 msec | 12 | 0.0293 | 0.656 | 0.622 | 0.034 |
| 2 | 250 msec | 12 | 0.0242 | 0.628 | 0.645 | -0.017 |
| 2 | 500 msec | 12 | 0.0236 | 0.634 | 0.634 | 0.000 |
| 2 | 750 msec | 12 | 0.0282 | 0.659 | 0.643 | 0.016 |
| CONTROL | ZERO | 10 | 0.0156 | 0.522 | 0.560 | -0.038 |
| YOUNG | 125 msec | 10 | 0.0216 | 0.502 | 0.476 | 0.026 |
| 3 | 250 msec | 10 | 0.0211 | 0.494 | 0.499 | -0.005 |
| 3 | 500 msec | 10 | 0.0297 | 0.491 | 0.488 | 0.004 |
| 3 | 750 msec | 10 | 0.0236 | 0.508 | 0.496 | 0.011 |

TABLE 12

DIFFERENCE SCORES IN THE COMBINATION CONDITION

| GROUP | TIME | TYPE | N | IMPROVEMENT (in MSEC) |
|---|---|---|---|---|
| DAT | 0 | 0 | 9 | 0.185 |
| | 0 | 1 | 9 | 0.099 |
| | 1 | 0 | 9 | 0.176 |
| | 1 | 1 | 9 | 0.217 |
| CONTROL | 0 | 0 | 12 | 0.028 |
| ELDERLY | 0 | 1 | 12 | 0.061 |
| | 1 | 0 | 12 | 0.024 |
| | 1 | 1 | 12 | 0.055 |

TIME: 0 = mean of 125 and 250 msec

1 = mean of 500 and 750 msec

TYPE: 0 = RT for correct rejections

1 = RT for hits

TABLE 13

Improvement In RT by Condition and Group

(in Msec)

CONTROL YOUNG

| INTERVAL LENGTH | | | | |
|---|---|---|---|---|
| CONDITION | 125 Msec | 250 Msec | 500 Msec | 750 Msec |
| Preparation | -9 | 20 | 16 | 14 |
| Encoding | 28 | 52 | 32 | 46 |
| Combination | 20 | 24 | 34 | 19 |

CONTROL ELDERLY

| INTERVAL LENGTH | | | | |
|---|---|---|---|---|
| CONDITION | 125 Msec | 250 Msec | 500 Msec | 750 Msec |
| Preparation | 6 | 4 | 21 | 18 |
| Encoding | 43 | 34 | 59 | 64 |
| Combination | 41 | 41 | 62 | 34 |

DAT GROUP

| INTERVAL LENGTH | | | | |
|---|---|---|---|---|
| CONDITION | 125 Msec | 250 Msec | 500 Msec | 750 Msec |
| Preparation | 28 | 61 | 97 | 84 |
| Encoding | 81 | 85 | 86 | 114 |
| Combination | 189 | 87 | 175 | 213 |

TABLE 14

Summary of Error Scores

| | CONDITION | | | |
|---|---|---|---|---|
| GROUP | TOTAL ERRORS | PREPARATION | COMBINATION | ENCODING |
| DAT | 19.8 | 7.3 | 7.3 | 5.1 |
| CONTROL ELDERLY | 7.8 | 2.2 | 3.0 | 2.6 |
| CONTROL YOUNG | 9.7 | 3.9 | 3.3 | 2.5 |

TABLE 15

T-Score Summary Variables

| GROUP | PREPARATION MEAN | COMBINATION MEAN | ENCODING MEAN |
|---|---|---|---|
| DAT | 5561 | 4623 | 4555 |
| CONTROL ELDERLY | 5545 | 4873 | 4363 |
| CONTROL YOUNG | 5376 | 5123 | 4347 |

FIGURE 1

Pilot Data

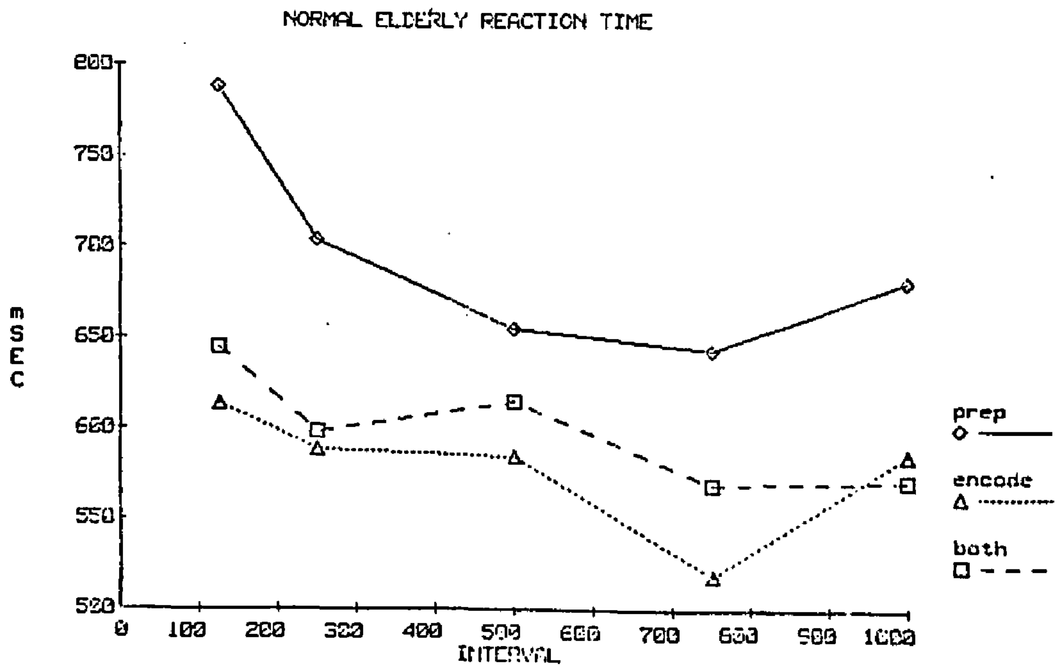


FIGURE 2

**Pilot Data**

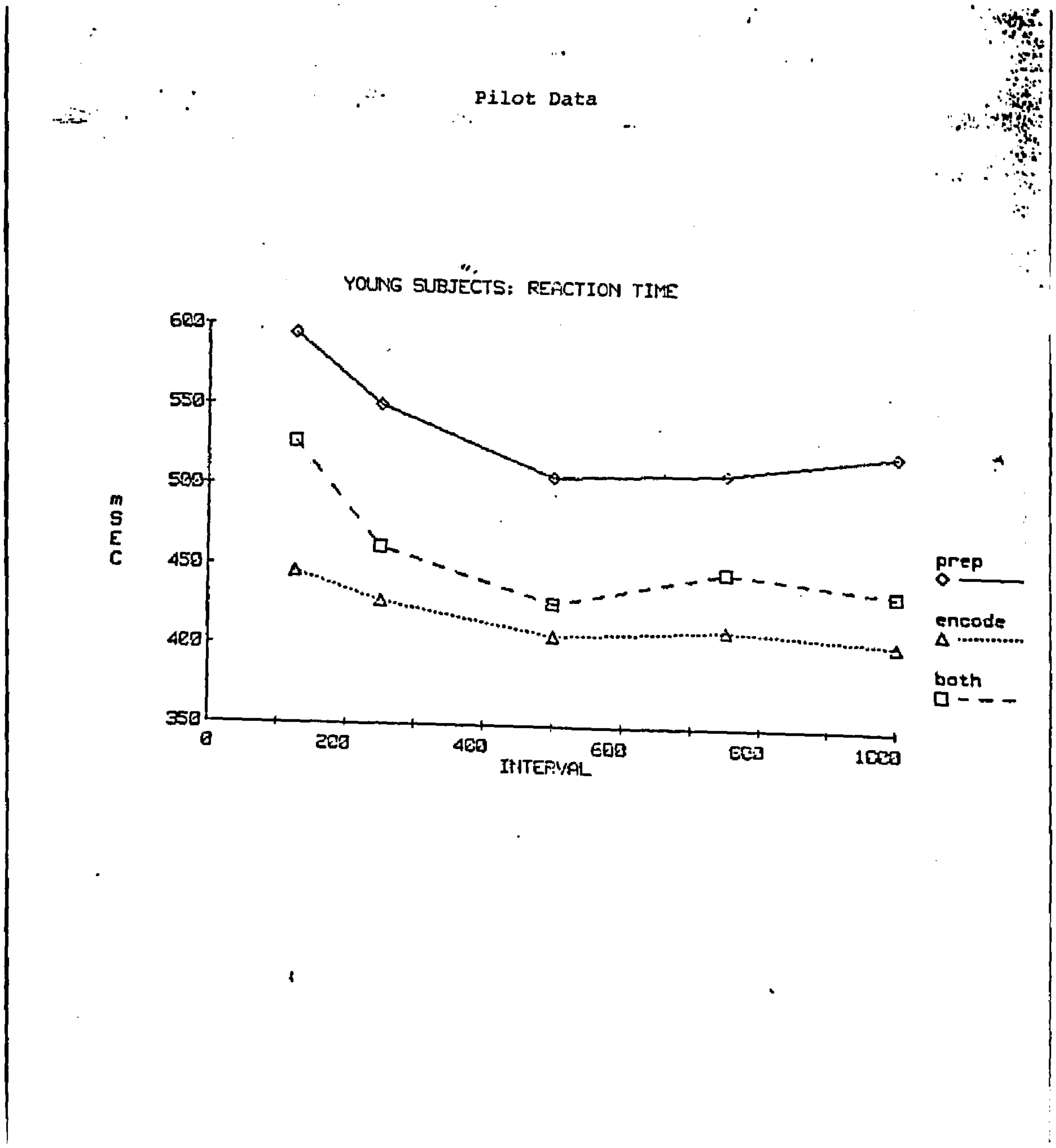


FIGURE 3

**Pilot Data**

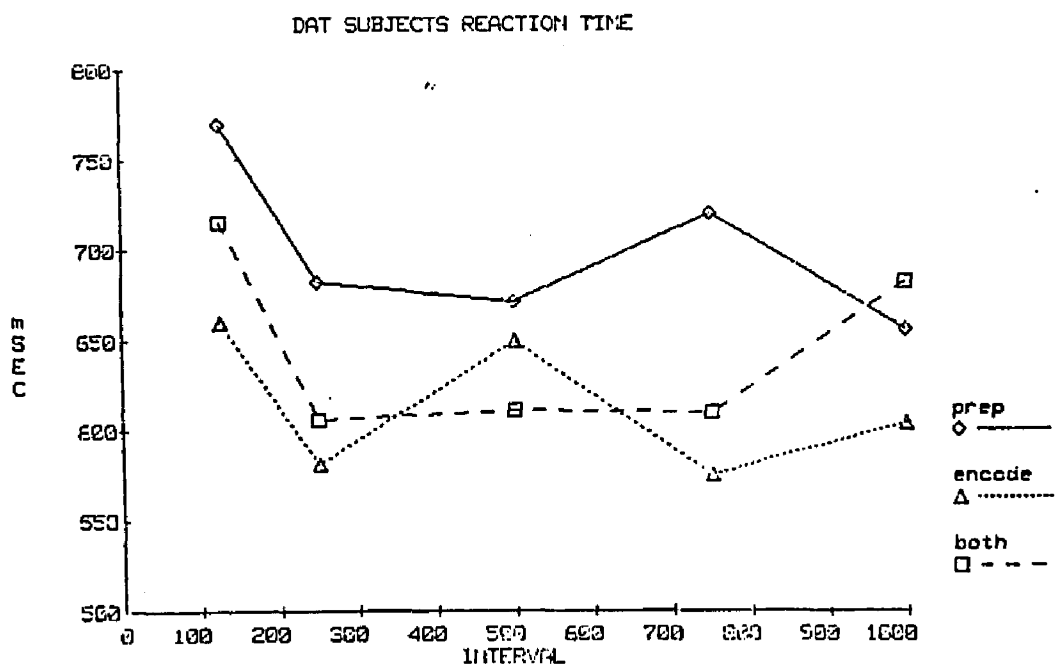


FIGURE 4

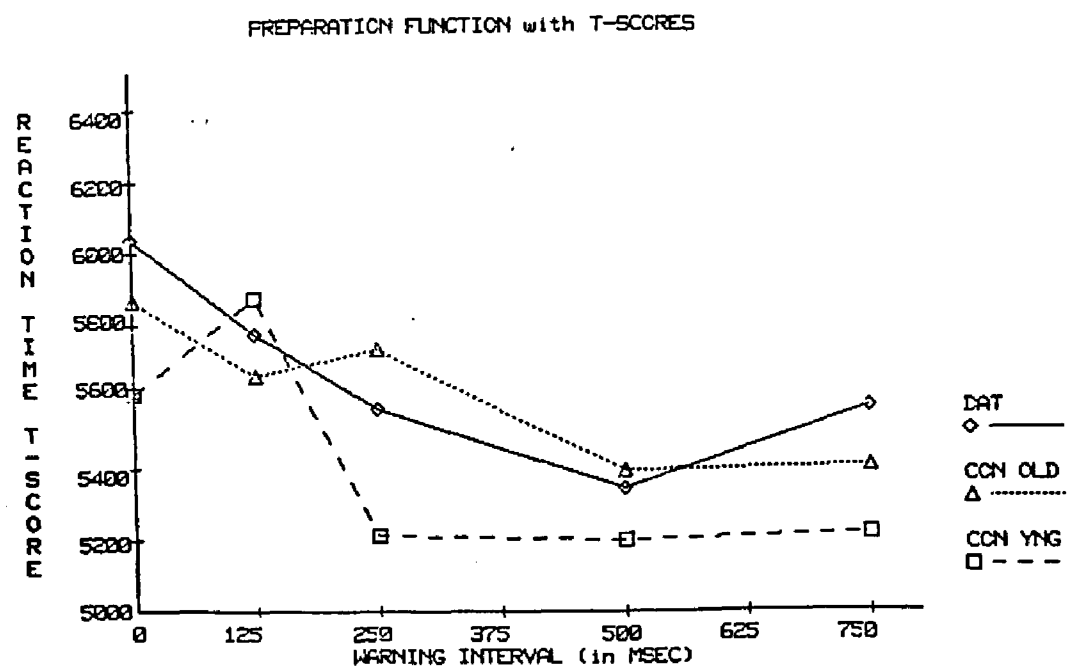

PREPARATION FUNCTION with T-SCORES
REACTION TIME T-SCORE
6400
6200
6000
5800
5600
5400
5200
5000
0
125
250
375
500
625
750
WARNING INTERVAL (in MSEC)
DAT
CON OLD
CON YNG

FIGURE 5

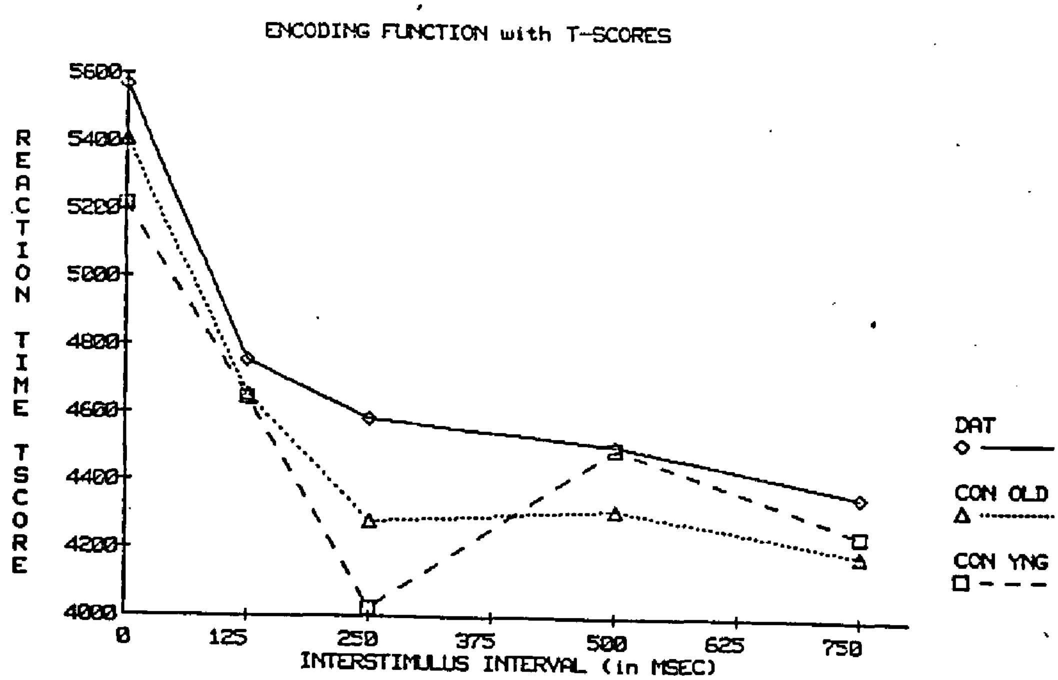

ENCODING FUNCTION with T-SCORES
REACTION TIME TSCORE
5600
5400
5200
5000
4800
4600
4400
4200
4000
0
125
250
375
500
625
750
INTERSTIMULUS INTERVAL (in MSEC)
DAT
CON OLD
CON YNG

FIGURE 6

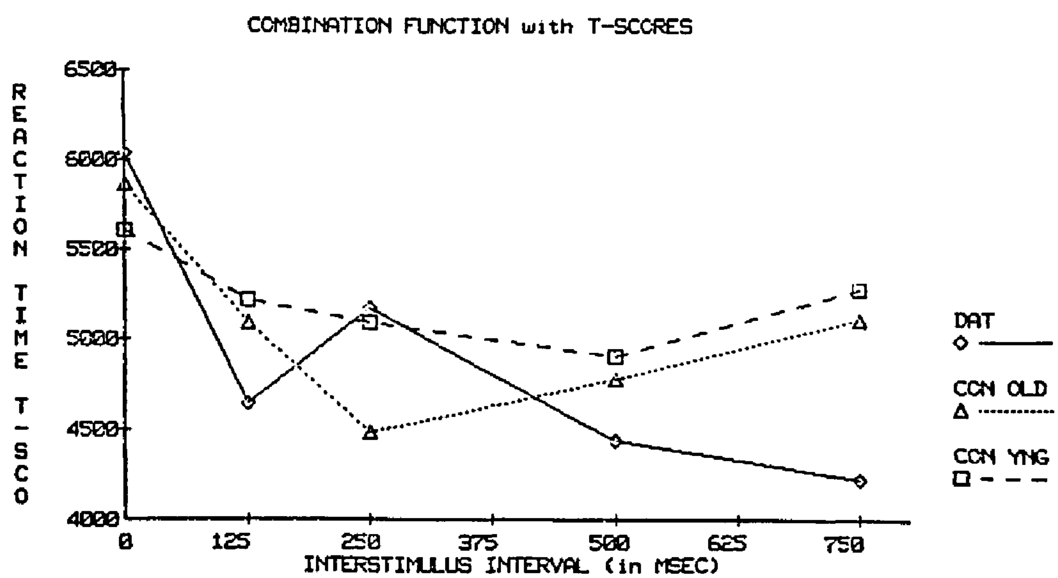
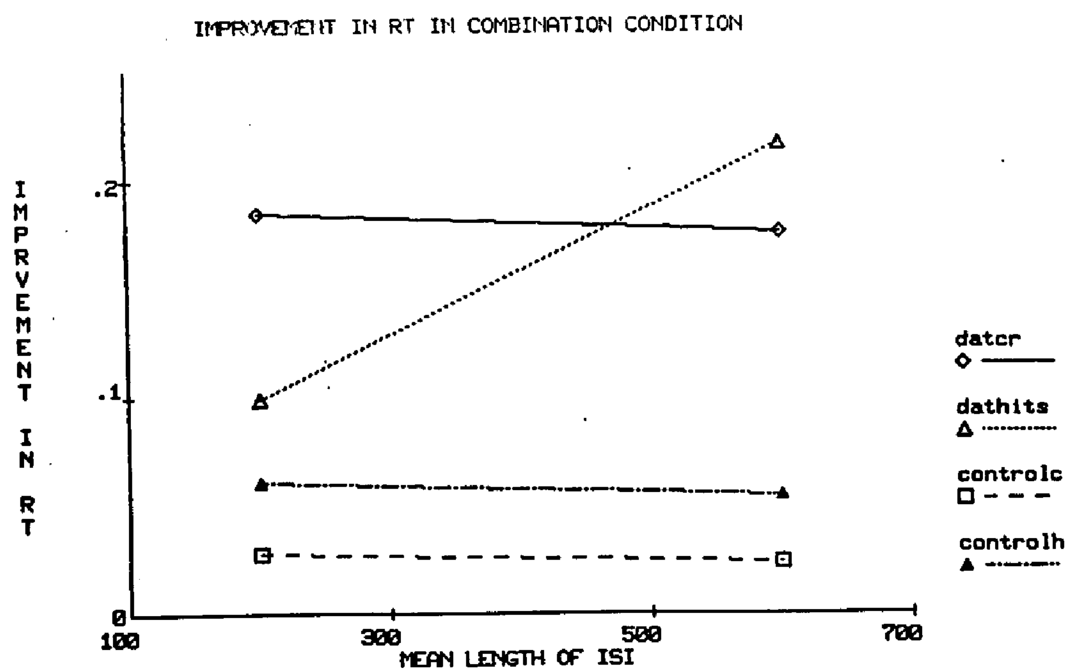

COMBINATION FUNCTION with T-SCORES
REACTION TIME T-SCO
6500
6000
5500
5000
4500
4000
0
125
250
375
500
625
750
INTERSTIMULUS INTERVAL (in MSEC)
DAT
CON OLD
CON YNG

FIGURE 7


IMPROVEMENT IN RT IN COMBINATION CONDITION
IMPRVEMENT IN RT
.2
.1
0
100
300
500
700
MEAN LENGTH OF ISI
datcr
dathits
controlc
controlh

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