Ph.D. Psychology

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Schizophrenic and normal changes with age in cognitive and psychomotor capacities were investigated by comparing the performance of younger and older chronic schizophrenics with younger and older normal subjects. There were 21 subjects in each group. The mean ages of the younger and older groups were 43 and 66 years respectively. The following tasks were administered: an oral fluency test, the McGill Picture Anomaly Series (M), a stepping-stone maze learning and retention task, a digit-span test, a dichotic listening task, and a tapping test. Both schizophrenia and age significantly reduced performance efficiency. Some schizophrenic deficits could be differentiated both in degree and in kind from normal age changes. The finding that the amount of change with age for the schizophrenic subjects was either the same as or less than that for the normal subjects demonstrated clearly that progressive deterioration even in nonparanoid schizophrenics is not a necessary concomitant of schizophrenia.

Change in Cognitive Capacity with Aging in Normal and Schizophrenic Adults

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Table of Contents

Introduction

The notion that schizophrenia is a disorder characterized by progressive deterioration is deeply ingrained in scientific and popular literature. Although some theorists have questioned this assumption, the evidence on the long-term course of the illness is meager. The purpose of this research was to investigate changes in certain aspects of cognitive functioning which accompany aging in schizophrenia and to compare these changes to those which occur in normal aging. It was hoped in this way to determine whether or not deterioration is in fact a necessary concomitant of schizophrenia, as well as to ascertain the extent to which deficits in schizophrenia resemble those observed in normal aging.

Schizophrenia is a diagnostic label that has been applied to one of the most severe and perplexing aberrations of human behavior. About 1 per cent of the general population may be expected to develop the disorder during their lifetime (Slater, 1968), and about 50 per cent of the resident populations in mental hospitals are currently classified as schizophrenic (Page, 1971). The importance of the problem is evidenced by the voluminous array of research on schizophrenia conducted during the last 40 years. Nevertheless our ignorance with respect to most aspects of the disorder is virtually total. Wender (1963) has aptly described the present state of confusion in this area:

> "The twentieth century historian surveying the concept of schizophrenia...does not know whether the term comprises one entity with one etiology, one entity with several etiologies, a group of similar entities with the same etiology, or a group of similar entities with different etiologies [p. 1143]."

The term "schizophrenia" refers to a class of disorders initially called démence précoce by Morel in 1860 and later dementia praecox by Kraepelin in 1896. Both nineteenth century psychiatrists were referring to a dementia which occurs at an early age; for Kraepelin, however, dementia praecox had the added connotation of inevitable intellectual deterioration. Kraepelin first subsumed under the general classification of dementia praecox three major subtypes--paranoid, hebephrenic, and catatonic, and later added a fourth--simple. The paranoid type he described as being characterized by unsystematic and bizarre delusions and hallucinations; the hebephrenic type by disorganized thinking, inappropriate affect, and silliness of behavior; the catatonic type by stupor and mutism; and the simple type by withdrawal, apathy, and inability to form personal attachments. Bleuler felt that in many cases there was neither early onset nor irrecoverable intellectual deterioration and therefore in 1911 renamed the disorder schizophrenia. Bleuler's description of the disorder and the currently accepted psychiatric description are in close agreement. Both consider schizophrenia to be a group of psychoses with characteristic disturbances of thinking, feeling, and behavior: thought processes may be disconnected and illogical; emotional responses may be inappropriate; and behavior may be withdrawn, regressive, and bizarre. The current tendency in psychiatry is to categorize the patient by means of his most predominant symptoms under one of ten subtypes which include the basic four described by Kraepelin. Modern psychologists, on the other hand, have pointed out that the diagnostic subcategories are unreliable and lack homogeneity (e.g. Rotter, 1954; Zigler & Phillips, 1961). Research since the early 1960's has focussed on the behavioral correlates of dimensions of schizophrenia which either cut across all or combine some of the traditional classifications.

Four dimensions have been studied--paranoid/nonparanoid, process/reactive, good and poor premorbid adjustment, and chronic/acute. The paranoid-nonparanoid dichotomy results when all nonparanoid classes are subsumed under one heading. The distinction between process-reactive according to Kantor, Wallner and Winder (1953) is that reactive schizophrenics have a more sudden onset, a more adequate premorbid personality, and a better prognosis. Good premorbid schizophrenics when compared to poor premorbid ones have a better personal adjustment prior to illness and are for the most part married (Phillips, 1953). An acute schizophrenic is generally one who has been in the hospital less than two years; after two years he is frequently called chronic because he has a lower probability of improvement (Brown, 1960).

The degree of independence of the four dimensions has not been fully elaborated although process-reactive, good-poor premorbid, and acute-chronic may represent a single dimension while paranoid-nonparanoid appears to be distinct from, and to cut across, the other three (Johannsen, Friedman, Leitschuh, & Ammons, 1963). Goldstein, Held, and Cromwell (1968) found that paranoids were predominately good premorbid patients while nonparanoids were almost equally distributed between schizophrenics with good and poor premorbid adjustment.

Attempts to subclassify schizophrenia have been hindered by the very limited information about the etiology of the disorder. Yet, without a clearer understanding of the number of distinct entities actually subsumed under the general heading of schizophrenia, progress along other fronts of schizophrenic research is impeded. Meehl (1962) has hypothesized that "schizophrenia, while its content is learned, is fundamentally a neurological disease of genetic origin [p. 837]." Evidence for a genetic cause comes mainly from studies in which the incidence of schizophrenia in relatives of the index case, usually one of twins, is determined. Rosenthal (1971) reviewed the results of eleven major twin studies on the inheritance of schizophrenia. Since the concordance rate was three to six times greater for monozygotic than for dizygotic twin pairs, he concluded that the findings provide "strong but not conclusive evidence of a genetic contribution to schizophrenia [p. 74]." Moreover, since the concordance rate for the monozygotic pairs was never 100 per cent, he also argued that environmental factors must also contribute.

Evidence for a genetic predisposition for schizophrenia has led some investigators to search for an underlying biochemical dysfunction. One notion has been that schizophrenics have in circulation in the blood a substance not found in normal adults. Heath (1960, p. 146), for example, attributed schizophrenia to the presence of a "qualitatively different protein (taraxein)", while Hoffer and Osmond (1959), attributed it to "adrenochrome" which is a byproduct of the faulty metabolism of adrenalin. Alternatively, it has been postulated that either increases or decreases from a basal level of a substance found normally in the brain--serotonin--would account for schizophrenic symptoms (Smythies, 1967; Woolley & Shaw, 1954). One very recent theory (Stein & Wise, 1971) has suggested that "episodic or continuous production of endogenous 6-hydroxydopamine... as a result of a genetically determined enzymatic error" leads ultimately to permanent damage to the noradrenergic reward system and "might cause the fundamental symptoms and long-term downhill course of schizophrenia [p. 1032]." At the present time there is no conclusive evidence in favour of any one of the existing biochemical theories.

One of the environmental factors implicated in schizophrenia is a breakdown of normal family relationships. Mothers of schizophrenics have been found to be overprotective or rejecting (e.g., Gerard & Siegel, 1950; Kasanin, Knight, & Sage, 1934; Mark, 1953); fathers have been found to be weak and ineffectual (e.g., Fleck, Lidz, & Cornelison, 1963; Kohn & Clausen, 1956; Lidz & Fleck, 1960; Lidz & Lidz, 1949). It has also been suggested that schizophrenic behavior is provoked by a pattern of communication, mainly with the mother, in which the individual continually receives contradictory pairs of messages on the same theme (Bateson, Jackson, Haley, & Weakland, 1956; Weakland & Fry, 1962).

Differences in family attitudes may be a relevant causal factor of schizophrenia only for middle-class groups. Lane and Singer (1959) compared familial attitudes of paranoid schizophrenics and normal subjects separately for both lower- and middle-class groups. Differences between schizophrenic and normal subjects in attitude toward family figures were infrequent for the lower-class groups, but were detected on 49 of the 59 variables investigated for the middle-class groups. If this is actually the case, then social-class differences in family attitudes cannot account for Hollingshead and Redlich's (1958) finding that schizophrenia was eight times as common in the lower as in the upper socio-economic class. After reviewing all of the evidence which attempts to establish a relation between social class and schizophrenia Kohn (1968) argued against the "drift" hypothesis and stated that the higher incidence of schizophrenia in the lower class was not caused by a decline in the social position of schizophrenics as a consequence of their illnesses. He felt instead that some aspect of lower class living increases the probability of the disorder.

Another approach to the description of schizophrenia is to study the functioning of schizophrenics on standard psychological tests. Research describing the functioning of the schizophrenic has generally found no sensory deficit to account for the delusions and hallucinations, but there is clear-cut evidence of rather widespread detrimental effects on various aspects of cognition. There is, in addition, some evidence that a motivational factor might on occasion affect performance and contribute to the deficit.

In general no deficit has been found on sensory threshold measurements. Tactile perception (Huston, 1934), visual acuity (Glickstein, 1966), and auditory thresholds (Travis, L.E., 1924; Travis, R.C., 1926) have all been found to be within the normal range. Although chronic and process schizophrenics have not been found to differ from normal subjects on critical flicker fusion thresholds (King, 1962; McDonough, 1960; Ricciuti, 1948; Venables, 1963), McDonough (1960) found that reactive schizophrenics tend to have significantly higher thresholds than normal subjects.

Shape, distance, and size constancies have all been investigated and because of conflicting results studies in this area of perception have failed to increase the present understanding of the psychological deficit in schizophrenia. For example, Weckowicz (1964) found a decrease in shape constancy for schizophrenics when a circle was inclined at 60°, but he found no difference between schizophrenics and normal subjects when the circle was inclined at 30°. Schizophrenics also overestimate distances when compared to normal subjects (Weckowicz & Hall, 1960; Weckowicz, Sommer, & Hall, 1958). The findings from size constancy experiments which compared a schizophrenic group of unspecified type with a normal control group have been inconsistent. Results were approximately equally divided between those which indicated that schizophrenics were over-constant (Perez, 1961; Sanders & Pacht, 1952), under-constant (Crookes, 1957; Hamilton, 1963; Weckowizc, 1957) or not different when compared with normal subjects (Leibowitz & Pishkin, 1961; Pishkin, Smith & Leibowitz, 1962). The results obtained by studies which differentiated the subtypes were also inconsistent. Although two studies (Rausch, 1952; Weckowicz & Blewett, 1959) found that paranoid schizophrenics showed overconstancy, these findings were not replicated by Jannucci (1965) or by Price and Eriksen (1966).

On traditional learning tasks schizophrenics have been found to be slower in the acquisition of paired associate lists (Hall & Crookes, 1951; Hull, 1917; Kapche, 1969; Spence & Lair, 1964). Hull (1917) administered a paired-associate learning task to 3 constitutional inferiors, 3 paretics, 3 dementia praecox patients and 9 summer session students. He found that the mental patients took longer to learn the task than the normal subjects but that after both groups had learned to criterion, there was no difference in recall one week later. In addition, the mental patients again took longer to relearn the material. He concluded that the deficit was in acquisition rather than in retention. The results from classical conditioning are equivocal. Investigators using eyeblink as the unconditioned response found either that schizophrenics conditioned more rapidly than normals (Spence & Taylor, 1953; Taylor & Spence, 1954) or that there was no difference between the groups (O'Connor & Rawnsley, 1959) whereas researchers working on GSR conditioning have generally found that schizophrenics condition more slowly and have a conditioned GSR of smaller amplitude (Howe, 1958; Peters & Murphee, 1954). Schizophrenics have also been found to be slower in the learning of motor tasks. Huston and Shakow (1948) gave schizophrenics repeated trials on a pursuit rotor task and found that their performance was slower and that they showed less improvement. Hall and Crookes (1951) found that they were slower in learning to pull a series of switches in the correct order.

Schizophrenics have been found to be poorer at rote memorization of short stories (Lloyd, 1961) as well as of series of words and their definitions (Shapiro & Nelson, 1955). Although they do not show a deficit on recognition of a word list, they are poorer on immediate recall after one presentation of a similar word list (Bauman & Murray, 1968; Nachmani & Cohen, 1969). The recall deficit has also been shown by Orgel (1956) for word lists, Lipton (1954) for stories and Rowell (1958) for picture series.

The question which must be considered is whether the schizophrenic's lowered performance on a variety of experimental tasks reflects an underlying deficiency in ability or whether it is caused by his insufficient motivation or lack of attention. One possibility mentioned by Buss and Lang (1965) was that whereas the normal subject perseveres at meaningless tasks simply to please the experimenter, the schizophrenic may not be similarly motivated. Studies of schizophrenic motivation have indirectly examined this possibility by focussing upon the relative effectiveness of various types of reinforcement. It was found that when encouragement and praise were given between tasks, the performance of schizophrenics on subsequent tasks slightly improved (Damankos, 1963; Olson, 1958; Stotsky, 1957). Noncontingent reinforcement, however, is generally less effective than contingent reinforcement. When schizophrenics were given success or failure feedback immediately after each response, censure was relatively more effective than praise in improving the schizophrenic's performance (Cavanaugh, Cohen, & Lang, 1960; Cohen, 1956; Leventhal, 1959); in some cases, praise had little or no effect (Cohen & Cohen, 1960; Slechta, Gwynn, & Peoples, 1963). Atkinson and Robinson (1961) and Koppenhaver (1962) found that censure was more effective whether it was given verbally or non-verbally. Although the performance of schizophrenics has been improved by positive and negative reinforcement, rarely has it attained the level of functioning seen in normal subjects. Even when the response is made contingent on the escape from or avoidance of such noxious stimuli as shock and white noise, most investigators have reported only a facilitation of the response (e.g. Cohen, 1956; Cowden, 1962; Foley, 1965; Karras, 1962; Lang, 1959; Rosenbaum, Machevey, & Grisell, 1957). A mere three studies have reported that the schizophrenics' performance actually reached normal levels (Brown, 1961; Cavanaugh, 1958; Pascal & Swenson, 1952). These improvements in the performance of schizophrenics may occur not because the schizophrenic is differently motivated or especially responsive to censure or pain but rather because more information about the task is provided from a knowledge of errors, and this additional information may be particularly useful to schizophrenics (Buss & Lang, 1965). O'Brien (1964) has found that there was a decrease in the superiority of censure as a reinforcement when the amount of information provided by praise was increased.

One problem which arises from an inspection of all of the studies which have examined deficits in schizophrenia is whether the deficit is specific to schizophrenia or just a concomitant of reduced efficiency which could be associated with any other illness or with normal aging. In order to examine the similarities and differences between schizophrenia and aging, it is necessary to consider the course of schizophrenia and the changes that occur in the schizophrenic as he grows old.

Most early theorists either made explicit statements about the course of schizophrenia or embedded in their theories certain implications about it. Kraepelin (1896) believed that the disorder followed a progressively deteriorating course. Bleuler (1911), on the other hand, believed that schizophrenia did not inevitably result in deterioration, but rather than the symptoms could occasionally flare up or be arrested, and that there could be either deterioration in the condition or temporary remission. Complete recovery, however, he felt was not possible. Meyer (1906, 1910), who considered that the disorder resulted from faulty learning patterns, seemed to imply that the deterioration might be reversed through relearning if the opportunity for relearning occurred. No matter what the theoretical position, however, it would be expected that the deficits concomitant with aging would overlie those associated with schizophrenia, although opinion on the relative rate of change with age for schizophrenics and normal subjects would differ. Since Kraepelin argued that schizophrenia followed a downhill course, he would predict greater deficits in old schizophrenics than in young ones. Both Bleuler and Meyer would predict that the deficit would be the same or less but certainly not greater in old schizophrenics than in young ones. Bleuler, in fact, was of the opinion that the organic diseases determined by age such as senile dementia did not occur to any marked degree in old schizophrenic patients. Bleuler's hypothesis has not been entirely substantiated by psychiatric evidence. Riemer (1950) examined 100 chronic schizophrenics over 65 years of age who had been continuously hospitalized for a period of 25 years. He reported that the incidence of senility, organic brain changes, and arteriosclerosis was extremely low. He noted, however, that schizophrenics who make periodic adjustments and return to the community were much more likely to develop senile psychosis. On the other hand, Muller (1963) found a high incidence of organic changes and senile dementia in the 101 old chronic hospitalized schizophrenics which he studied.

There has been very little investigation of change in symptomatology with age. Psychiatric evidence, however, does not support the deterioration notion. Both Muller (1963) and Bychowski (1952) reported that many elderly schizophrenics showed no alteration in symptoms. When changes did occur in the delusional system, Muller found that the type of change was unpredictable: in some patients the delusion disappeared, while in others the delusion was expanded or consolidated.

One early psychological study attempted to find evidence to support the notion that schizophrenic patients may be described as "prematurely old". Margaret (1942) compared the Wechsler-Bellevue intelligence test performance of 30- to 40-year-old schizophrenics with normal subjects of comparable age from Wechsler's standardization sample. The schizophrenics were found to be significantly poorer on 8 of the 11 subtests. She reported that the direction of change of the significant tests for the schizophrenic group was similar to that found when older normal subjects (40-49 years) were compared to younger normal ones (20-29 years). She concluded that certain tests were "sensitive to whatever changes in the organism occur similarly in schizophrenia...and increasing age [p. 528]." This finding has not been confirmed by a more recent study (Berger, Bernstein, Klein, Cohen, & Lucas, 1964) in which four separate factor analyses were carried out on the Wechsler Adult Intelligence Scale (WAIS) protocols of 100 pseudoneurotic, 180 chronic and 100 acute schizophrenics, and 100 brain damaged subjects between the ages of 20 and 40 years. The factorial structure of each group was then compared with the factors obtained when the scores of each of four selected age groups--the 18- to 19-year-olds, the 25- to 34-year-olds, the 45- to 54-year-olds, and the 60- to 75-year-olds--from the Wechsler standardization sample were factor analysed. The results showed that although the Verbal and Perceptual Organization factors were less vulnerable to both pathology and age changes than the Memory/Freedom from Distractibility factor, there were greater changes in factorial structure associated with normal aging than there were with pathology.

Since 1896 when Kraepelin suggested that intellectual deterioration was a striking feature of dementia praecox, psychologists have been investigating three aspects of the intellectual deficit which has been rather narrowly defined as the loss in scores obtained on conventional tests of intelligence. The evidence suggests that the intellectual deficit does not precede the disorder but rather accompanies its onset. Studies have reported that children who later become schizophrenic had lower intelligence levels than their peers and siblings (Albee, Lane, Corcoran, & Wernike, 1963; Albee, Lane, & Reuter, 1964; Birren, 1944; Lane & Albee, 1963, 1964, 1965). On the other hand, studies of the premorbid intellectual functioning of schizophrenics as teenagers (Rappaport & Webb, 1950) or as adults (Lubin, Gieseking, & Williams, 1962) have not detected any pre-illness deficits. Moreover, Lane and Albee (1968) have raised doubts about their own earlier results by demonstrating that the premorbid differences between peers disappear when the groups are composed of children equated for socio-economic class.

An intellectual deficit, nevertheless, does appear with the onset of schizophrenia. In summarizing the literature on intellectual loss Winder (1960) has estimated that there is an average deficit of 10 I.Q. points when schizophrenics are compared to a matched control group. Longitudinal studies have also reported intellectual deficits after the onset of schizophrenia (DeLuca, 1967; Lubin et al., 1962; Rappaport & Webb, 1950; Schwartzman & Douglas, 1962). These studies found a deficit on retest between schizophrenics and a group of normal control subjects matched on age and the available premorbid intellectual scores.

Hunt and Cofer (1944) reviewed the early evidence on intellectual deterioration and concluded that progressive loss might not be a necessary concomitant of schizophrenia. More recent evidence from longitudinal studies suggests, however, that their conclusion requires qualification. Schwartzman, Douglas, and Muir (1962) have found that while former patients showed recovery from intellectual losses, current patients continued to show further losses. Occasional improvement rather than deterioration in the intellectual performance of hospitalized schizophrenics has been reported after 2 years (Foulds & Dixon, 1962b), 8 years (Smith, 1964), and 14 years (Hamlin, 1969). Other studies using vocabulary as the measure of intelligence found no change after 6 years (Moran, Gorham, & Holtzman, 1960) or even after 13 years (Ginett & Moran, 1964). These conflicting reports may be a function of the ratio of improved to unimproved patients in the sample under investigation, since Haywood and Moelis (1963) have reported that improved patients showed intellectual gains relative to their admission scores, while unimproved patients showed relative losses.

Two studies have considered the rate of intellectual change with age in schizophrenic and normal subjects. As part of a study of the nature of the intellectual deficit in schizophrenia, Foulds and Dixon (1962a) plotted the performance of their schizophrenic and neurotic subjects on the Progressive Matrices Test and the Mill Hill Vocabulary Test as a function of age and graphically compared the changes to the standardization sample. Since the slope of the curves for all three groups was similar, they concluded that the intellectual decline in schizophrenia was not progressive but rather that the decline could be accounted for by aging. The oldest subjects in this study were sixty years of age.

A slower rate of aging in schizophrenics has been reported by Binder (1956). In a well controlled study he administered the SRA Tests of Primary Mental Abilities (Intermediate) developed by the Thurstones (Thurstone, L.L. & Thurstone, T.G., 1949) to a younger and older group of schizophrenics and a younger and older group of normal subjects. The younger group was composed of individuals under 39 years of age with a mean of approximately 28.5 years, and the older group was composed of individuals over 40 with a mean of approximately 52.8 years. Binder found that while the younger schizophrenics were significantly poorer than the younger normal subjects on all the tests, the older schizophrenics were only poorer on four of the five tests. In addition, the deficit of the schizophrenics in the younger group was relatively greater than the deficit of the schizophrenics in the older group. Although the performance of the older normal group was always much poorer than the younger normal subjects, on one of the five tests the performance of the older schizophrenics was slightly but not significantly better than the younger schizophrenics. To compare the schizophrenic and normal groups on differential impairment of intellectual function, he removed the results of three of the tests from the other two by means of analysis of covariance. He then found that the age decline for the normal subjects on the Space and Reasoning tests was greater than could be accounted for by the decline on the other tests, while the age decline for the schizophrenics could be accounted for entirely by their decline on the other three tests. He therefore concluded that although there is differential impairment of intellectual functioning as a result of normal aging, "there is some factor concomitant with schizophrenia that causes great enough over-all impairment of intellectual functioning to mask any differential effects of aging upon the various functions [p. 139]."

The purpose of the present research was to examine the changes with age in the cognitive functioning of schizophrenics. Despite the fact that the theories of Kraepelin and others have stressed the progress of the disorder, there has been little work done to test the implications of their theories. The largest body of research which might be considered relevant here is that on intellectual deterioration in schizophrenia. The longitudinal studies of deterioration (with the exception of that of Hamlin's, 1969), however, did not test subjects over 45 years of age; they can, therefore, hardly be considered studies of the elderly. Moreover, because they all lacked a normal group of comparable age retested after the same period of time, aging effects were confounded with the effects of changes in pathology. Of the two cross-sectional studies on intellectual change with age one study (Foulds & Dixon, 1962a) apparently relied on the standardization sample for its normal data, while in the other (Binder, 1956) the mean age in the older group was only 53 years. Since in normal individuals there is generally an accelerated decline with age after about 60 years, in any study of changes with age the older subjects should be at least 60 years old. Accordingly, the paradigm adopted in the present study involved the use of both younger and older normal control groups matched on age, sex, and education to two schizophrenic groups, with "older" defined as being at least 60 years of age.

It would appear that only one study in the literature tested elderly schizophrenics over 60 years of age using a similar paradigm. The behavior studied was limited, however, to psychomotor tasks. The study is of interest because of the suggestion in the results that the performance of older schizophrenics was better than that of younger schizophrenics. King (1954) compared the performance of 20- to 70-year-old normal and schizophrenic subjects on several measures obtained from three tests of psychomotor capacity--reaction time, tapping, and the Purdue Pegboard Test. The results of the normal subjects were plotted as a function of age. In general he found that the psychomotor performance of normal subjects decreased in the older age groups. In addition, the combined group of chronic schizophrenics was slower and more variable than the combined group of normal subjects on all measures. When he divided the schizophrenic group at 45 years of age into an older and younger group, he noted, however, that on two measures (tapping and reaction time) the older schizophrenic group performed more quickly than the younger schizophrenic group.

The type of deficits which generally accompany normal aging have heen reviewed by Botwinick (1967, 1970) and Birren (1964). These authors concluded that normal aging results in changes in most areas of functioning. There is a general impairment in sensory capacity: auditory thresholds are higher (Dittrich & Fumeaux, 1965; Melrose, Welch, & Luterman, 1963) and hearing is impaired especially at the higher frequencies (Schaie, Baltes, & Strother, 1964); the visual field is restricted (Burg, 1968), recovery from glare is slowed (Burg, 1967), and critical flicker fusion thresholds are lower (Botwinick & Brinley, 1963; Huntington & Simonson, 1965;

Jalavisto, 1964; Simonson, Anderson, & Keiper, 1967; Wilson, 1963). A general finding in most studies is a slowing of response and this seems to be independent of the type of overt response required: the slowness in psychomotor behavior depresses reaction time (Botwinick & Thompson, 1966, 1968; Deupree & Simon, 1963; Weiss, 1965) and tapping (Csank & Lehmann, 1958; Jarvik, Kallmann, & Falek, 1962; King, 1954), while the slowness in giving associations reduces fluency (Birren, Riegel, & Robbin, 1962). Older persons are generally slower to learn new material and the deficit is increased the faster the stimulus pacing (Arenberg, 1965, 1967a, 1967b, Canestrari, 1963; Eisdorfer, 1965; Eisdorfer, Axelrod, & Wilkie, 1963; Taub, 1967) and/or the more difficult the task (Kausler & Lair, 1966; Ross, 1968; Zaretsky & Halberstam, 1968). Although it has been shown that there is an immediate memory deficit in old age (Craik, 1965; Inglis & Ankus, 1965; Inglis and Caird, 1963; Mackay & Inglis, 1963) and that most tests of memory show a decline with age (Bromley, 1958; Gilbert, 1941; Hulicka, 1966; Peak, 1968), the evidence regarding a long term storage deficit after learning to criterion is inconclusive. Most studies do not find memory deficits after 15 or 20 minutes (Hulicka & Weiss, 1965; Wimer & Wigdor, 1958). The results of studies that have examined memory losses after longer time periods, however, are inconsistent; some find deficits after a 24-hour (Hulicka & Rust, 1964; Wimer, 1960) or one week (Hulicka & Rust, 1964) delay, while others do not (Desroches, Kaiman, & Ballard, 1966; Hulicka & Weiss, 1965). Concept attainment and problem solving are generally impaired (Arenberg, 1968; Bromley, 1967; Sanders, Laurendeau, & Bergeron, 1966; Wiersma & Klausmeier, 1965); inefficient strategies are used (Rabbitt, 1964) and strategies which are repeatedly demonstrated cannot be applied (Young, 1966). Although intellectual decline is not always seen before middle age (Thumin, 1968), the rate of decline increases after the age of 60 (Doppelt & Wallace, 1955; Horn & Cattell, 1966; Miles and Miles, 1932; Norman, 1966; Orme, 1966). It has also been shown that intellectual decline in the aged is greater on performance than on verbal tests (Hallenbeck, 1964; Kelley, 1965; Norman, 1966), and is greater on tests of problem solving than on tests of stored information (Reed & Reitan, 1963).

Rationale for Test Selection

The main concern of the present study was to assess qualitative differences in cognitive capacity with aging in schizophrenic and normal adults. Task selection was based on two prime considerations--their sensitivity to aging in normal adults, and their representation of a range of cognitive functioning wider than that normally assessed by conventional intelligence tests. Tasks were chosen to represent distinct and important aspects of cognition, both verbal and nonverbal. Thus, nonverbal tests of intelligence (the McGill Picture Anomaly Series) and complex trial-and-error maze learning and retention were included, along with verbal tests which measured either retrieval of familiar words from long-term storage (verbal fluency), or registration, retrieval and reorganization of digits from immediate or short-term memory (digit-span and dichotic listening tasks). In general, instructions were kept to a minimum since both schizophrenic and elderly subjects are said to have difficulty in understanding and remembering them. In the one exception, where more detailed instructions were required, the instructional errors themselves were of interest.

The dichotic listening task was of special interest because it provides information both on auditory retention and on the nature of the organization imposed on auditory verbal input. In the typical dichotic listening situation pairs of stimuli, usually numbers, are played to the subject through headphones in such a way that one stimulus arrives at the left ear at the same time as the other arrives at the right ear. If the material is presented rapidly at a rate of 1 pair/½ sec., the subject adopts an ear order method to report what he hears, that is, he reports all the numbers from one ear before reporting any from the other ear (Broadbent, 1957). If the presentation rate is slowed to 1 pair/2 sec., however, the most common strategy is to use a temporal order of report in which the material is reported in the order of arrival at the ears (Broadbent, 1954; Bryden, 1962). College students have been reported to use ear order report for fast presentation rates and temporal order report for slow presentation rates whether the stimuli are numbers (Bryden, 1962, 1964) or words (Bryden, 1964). Bryden (1962) has also shown that as the amount of material contained in a series increases, subjects resort increasingly to strategies which consist of combinations of ear and temporal order at the expense of the pure ear and especially the pure temporal strategies. To account for the relation between report strategy and presentation rate Broadbent (1958) has proposed a model the main elements of which are a limited capacity channel (p-system) which simply relays information and is "involved in memory span", and a short-term memory storage system. He has suggested that when dichotic stimuli are presented rapidly, only material arriving at one ear can be attended to and perceived as it arrives, because of the limited capacity of the p-system. As a result, material arriving at the other ear must be held in the short-term memory storage, and then can be perceived only after the first channel is recalled and provided that the memory traces have not decayed.

Inglis and his colleagues (Inglis & Caird, 1963; Mackay & Inglis, 1963) have used the technique of rapid presentation of dichotic material to investigate whether some of the performance deficits in old age are a result of changes in the perceptual or the storage systems. They presented dichotic material at a fast presentation rate of 1 pair/ 2/3 sec. to subjects from 11 to 90 years of age. The amount of material in a series was varied systematically from one pair through six pairs. The scoring system for accuracy of report was based on the expectation that subjects would attempt to use an ear order report. Provided that the first number given by the subject had been one of the first pair presented, it was used to designate the first channel, and digits were then scored correct only if they were in the appropriate position in the series for the first channel, and then for the second one. The actual incidence of ear order report, however, was not given. In general, they found that the longer the series of numbers presented to the subject, the greater was the loss of material from the ear reported second. Of greater importance was their discovery that although there was no significant impairment in the ability of older subjects to recall material from the ear reported first, accuracy in reporting digits for the ear reported second decreased with age. The loss of material from the second channel was attributed to decreased efficiency of the short-term storage system. In a subsequent study of 120 subjects between 11 and 70 years of age Inglis and Ankus (1965) ruled out alternative explanations for the progressive second channel deficit with increasing age in terms of selective hearing impairment in the aged, or the inability of the elderly to attend to both channels, by specifying, either before or after the presentation of the digits, the ear to be reported first. In both conditions the impairment was found to occur in the ear reported second. Since subjects of all ages were equally accurate on the ear reported first, Inglis had earlier (Inglis, 1964) argued that it was unlikely that the impairment shown by the older subjects resulted from lack of motivation. The finding of a decrement in dichotic listening performance in the elderly has received additional confirmation from other studies (Broadbent & Gregory, 1965; Caird, 1965). On occasion, however, deficits have also been reported in the first channel (Craik, 1965; Inglis & Tansey, 1967).

Although it has been reported that a mixed group of elderly depressive and schizophrenic patients showed less deficit than senile patients on material from the ear reported second (Caird & Inglis, 1961; Inglis & Sanderson, 1961), schizophrenics have apparently never been compared to normal adults with respect to any aspect of dichotic listening performance. One interest of the present study, therefore, was simply to determine the nature of the organization imposed by schizophrenics on material presented dichotically at different speeds. Moreover, despite the body of research reported by Inglis and his co-workers, there is no information in the literature concerning the relation between presentation rate and report strategy in elderly normal adults. Another interest of the study then was to investigate whether any changes in organization occurred in old age. The presentation rates used--1 pair per ½ sec., 1 pair per sec., and 1 pair per 2 sec.--were those found by Bryden to be effective in demonstrating the transition from ear order to temporal order of report in college students. Since amount of material has been shown to affect the relative frequency of both kinds of report, it was decided to present series containing three different amounts of material at each presentation rate. Two of the series' lengths--the 3- and 4-pair--were chosen to coincide with those studied by Bryden. The 5-pair length used by him, however, was considered inappropriate for the schizophrenic and older subjects of the present study. Accordingly, a very short length of 2 pair per series was substituted in order to make the task as a whole less demanding.

Three forward digit-span tests were also administered to provide measures of immediate memory capacity for digits at each of the presentation rates used for presenting the dichotic listening stimuli. These tests differed from the dichotic listening task mainly in that the same series of numbers was heard by both ears, so that recall required no reorganization of the material.

On the Wechsler intelligence tests (Wechsler, 1944, 1955) digits in the digit-span subtest are presented at the rate of 1 digit/1 sec., and measures are obtained for both forward and backward recall. In the standardization sample of the WAIS for normal adults over 60 years of age a consistent decline in performance on the digit-span subtest from 60 to 75 years of age was reported (Doppelt & Wallace, 1955). Although Doppelt and Wallace did not study younger subjects, they pointed out that, in general, the performance of their subjects on digit span was poorer than that of the younger subjects in Wechsler's standardization sample. Two studies of aging have reported the results of forward and backward digit span separately. Although both studies found significant loss in ability to recall digits in a backward direction, the results on forward digit span were inconsistent. Gilbert (1941) found a slight, but still significant, deterioration with age in a comparison of 20- and 60-year-olds, while Bromley (1958) found no difference between 27- and 66-year-olds. Bromley reported that the mean digit span for forward recall was 6.6 for the old group and 6.8 for the young group.

Studies in which the performance of schizophrenic and normal subjects have been compared on the Wechsler digit-span subtest have produced contradictory results. Two of these studies compared the results of schizophrenics with those obtained from a normal group of the same age range tested as part of the standardization sample. One study found that a group of 30- to 40-year-old schizophrenics were poorer on digit span (Margaret, 1942), while the other found no difference for 30- to 49-year-olds (Olch, 1948). On the other hand, Olch (1948) did find that 17- to 29-year-old schizophrenics performed more poorly. Harper (1950) found that schizophrenics were actually better on digit span than a group of normal subjects that were matched for age and full scale I.Q. Although Cohen (1950) reported the forward and backward digit-span data separately for a schizophrenic group, he did not test the significance of the difference between them. It is of interest to note that his schizophrenic group with a mean age of 28 years and average intellignece was able to report as many digits (6.3) in a forward direction as Bromley's normal subjects.

The rate at which digits are presented is known to affect recall in normal adults. Conrad (1957) presented 8-digit numbers to college students at a fast rate of 1 digit/ 2/3 sec., and a slower rate of 1 digit/ 2 sec. He found poorer recall with the slower presentation rate under both a free and a paced recall condition. Slight differences in presentation rate have been found to be critical in determining whether or not age effects will be demonstrated. Fraser (1958) also presented 8-digit numbers, but at speeds of 1 digit/½ sec. or 1 digit/ 1½ sec., to a younger group comprised of 18- to 29-year-olds and an older group comprised of 30- to 55-year-olds. Under these conditions only the 30- to 55-year-olds showed poorer recall at the slower presentation rate. Moreover, the older subjects performed more poorly than the younger ones only at the slow presentation rate. While the presentation rates in the present study were determined by those selected for the dichotic listening tasks, the rates used--1 digit/½ sec., 1 digit/1 sec., and 1 digit/2 sec.--were within the range that has been found to be sensitive to age. While the older normal subjects were expected to show poorer performance, at least, when the presentation rate was slowed from 1 digit /½ sec. to 1 digit/2 sec., it was difficult to predict in what way changes in presentation rate would affect the performance of schizophrenics of either age group.

A maze learning task was used to investigate certain aspects of complex trial-and-error learning and retention. The stepping-stone maze used in the present study was modelled after one described by Barker (1931). The subject was required to learn to tap out a route in 28 discrete steps, by touching with a stylus the heads of some of the screws that studded the entire surface of the maze at 1-in. intervals. The correct path was differentiated visually only with respect to the starting and finishing points. Information about errors was given only by means of a click produced when the stylus touched a screw not in the correct sequence. Therefore, in addition to trial-and-error learning capacity performance on the maze would also involve, and be sensitive to, deficits in either spatial ability or memory.

Information concerning maze-learning deficits in schizophrenic and older normal subjects has come from studies of performance on paper-and-pencil mazes of different types which have varied in the extent to which spatial ability, memory, and trial-and-error learning were involved. Performance on the Porteus Maze Test has been shown to decline gradually between the ages of 25 and 50 years, and rapidly thereafter (Heston & Cannell, 1941). In addition to spatial ability, this test, which is comprised of a series of progressively more difficult age-graded mazes, primarily involves planning ability or implicit trial-and-error, since each trial is terminated with the first mistake in tracing the correct path, and the score obtained is determined by the level at which the subject fails to complete one errorless trial in two attempts. In another study of performance on a maze which involved primarily memory and instrumental learning ability 50-year-olds took longer to reach criterion than 22-year-olds (Wright, 1957, cited in Jerome, 1959). The maze in question was a 12-choice-point linear maze which was presented by means of a memory drum at the rate of one choice-point every 2.8 sec. One criticism made of this experiment was that the deficits Wright found in the older subjects might not have been completely attributable to a learning or memory deficit since their efficiency might have been affected by the pacing speed. There has been apparently only one previous study of maze learning performance in schizophrenics. Campbell (1957), according to a summary in Jones (1961), found that schizophrenics given repeated trials on paper-and-pencil mazes of three different levels of difficulty showed a learning effect over trials. Their performance on all three tasks, however, was consistently slower than that of the normal control group, with the difference between the groups being most marked on the initial trials.

The available evidence suggested that the schizophrenic and older normal subjects of the present study would experience greater difficulty than the younger normal group in learning the maze. Provided that subjects in all groups manage to learn the maze to the same criterion, however, it was considered that the task could then legitimately be used to assess differences in memory. In order to investigate 24-hour retention as well as acquisition, therefore, subjects were required to learn the maze initially to a criterion of two errorless trials, and then to relearn it to the same criterion one day later.

One important feature of the stepping-stone maze was that it permitted study of the nature of the errors made by the subject. Milner (1965) used the same maze to compare the performance of a normal control group and five groups of patients with brain lesions classified as either frontal, left temporal, right temporal, parietal, or right parieto-temporo-occipital. She found that patients with frontal lobe damage made both more rule-breaking errors and more repetitive errors than any of the other groups. Since schizophrenics generally have more difficulty in following instructions and tend to perseverate, one interest of the present study was to determine whether schizophrenics would demonstrate greater difficulty in following instructions and make more repetitive errors than normal subjects.

A verbal fluency test was included as a measure of the ability to retrieve and produce familiar verbal information rapidly. In general, the verbal fluency tests commonly used require subjects to say or write as many responses as possible within a set time limit. Two types of fluency tasks have been used: a completely unrestricted task which simply involves the naming of words, and tasks which involve somewhat more constraint: either naming words that begin with a particular letter of the alphabet, or naming nouns that are members of a particular class such as "animals". What is measured by such tests is not precisely known. In a factor analytic study of 56 tests administered to college students, Thurstone (1938) isolated word naming as a separate factor of general intelligence distinct from a verbal factor essentially comprised of vocabulary, comprehension, and reasoning. On the other hand, when verbal fluency deficits have been discussed, the emphasis has been on the continuous motor response component of the tasks, and the deficits themselves have tended to be attributed to a lowering of general activity level (Payne, 1961; Yates, 1961). Other investigators (Birren, 1955; Birren, Riegel, & Robbin, 1962) have attributed the deficit to interference from inappropriate responses because of a diminished ability to inhibit them.

Schizophrenics have only been tested on the completely unrestricted task once. Eysenck (1952) found no difference between schizophrenic and normal subjects asked to say as many words as possible in a three-minute period. Deficits, however, have generally been found on both oral and written verbal fluency tests involving more constraint. The Eysencks have reported that psychotics were less fluent than normal adults when naming animals, plants, or trees for one minute but were equally fluent when asked to name flowers; approximately half the subjects in each sample were diagnosed as schizophrenic (Eysenck, H.J., 1952; Eysenck, S.B.G., 1955, cited in Yates, 1961). Moreover, in the study by Binder already cited (Binder, 1956), both pathology and age differences were reported on the word naming subtest of the SRA tests of Primary Mental Abilities (Intermediate) which required the subject to give as many words beginning with the letter S as he can think of in a five-minute period. Binder found that young and old schizophrenics were less fluent than normal adults of equivalent ages, and that the deficit in the younger schizophrenics was relatively greater. Normal older subjects have been reported to show a deficit both on written fluency tests in which they were restricted to words beginning with a specified letter (Birren, 1955; Schaie, 1958; Strother, Schaie, & Horst, 1957; Riegel, 1959) and on the completely unrestricted task given orally (Birren, Riegel, & Robbin, 1962).

It was decided to include two indices of verbal fluency in the present study for the purpose of obtaining measures of both types of verbal fluency. A second and more important consideration was to obtain information about the performance of schizophrenics on tests which have given divergent results. Thus, both a more constrained task (animal naming) on which schizophrenics have consistently shown a deficit, and a completely unrestricted task (word naming) on which they have been tested only once but have been shown to be equally fluent, were administered. An oral rather than a written response was required in order to eliminate the additional motor component involved in written forms of verbal fluency tests.

The McGill Picture Anomaly Series (Hebb & Morton, 1943) was included as a nonverbal measure of social intelligence. The test consists of a series of cartoon-like pictures depicting obvious social errors or absurdities such as a refreshment stand in a graveyard. To recognize the incongruity requires an examination of the picture and some inductive reasoning as to the nature of both the picture as a whole and the reason for the anomaly. For the standardization sample, comprised of 100 subjects ranging in age from 16 to 65, Hebb and Morton reported that performance deteriorated after 40 years of age. Although schizophrenic and normal subjects have not been compared on the McGill Picture Anomaly Series, schizophrenics have been found to show a deficit on the picture absurdities subtest of the Canadian Army 'M' (Penrose, 1945; Schwartzman & Douglas, 1962), and to make inappropriate choices on the Healy Pictorial Completion Test which involves inserting the parts missing in pictures of scenes in a boy's daily life (Hanfmann, 1939a, 1939b). These data suggest that schizophrenics might be expected to show a deficit on the McGill Picture Anomaly Series.

One noncognitive measure--a tapping test--was included. Both age and pathology deficits have been reported on tapping tests of various types which are considered to reflect fine motor performance. Csank and Lehmann (1958) in a study of telegraph key tapping in normal subjects ranging in age from 5 to 80 years found that after the age of 50 there was a slight but significant decline in proficiency from the high level characteristic of the younger adult. Within the elderly age range itself a significant deterioration in pencil tapping performance has been observed between the ages of 67 and 75 when the same subjects were retested (Jarvik, Kallmann, & Falek, 1962). In addition, schizophrenics have been reported to tap more slowly than normal adults when the task consisted of tapping from side to side either on two telegraph keys (Shakow & Huston, 1936) or on two metal plates (King, 1954). King's data suggested that although his normal subjects showed a decrease in tapping speed with age, his schizophrenic subjects might in fact have improved with age. It was, therefore, decided to include a tapping test to investigate the possibility that age might affect the psychomotor performance of normal and schizophrenic subjects differentially. The tapping test selected for use required an alternating movement made with a stylus between two metal plates. This particular test was chosen simply because the movement involved resembled most closely that used in tapping the path on the maze.

In summary, the present study investigated change in cognitive capacity with age in schizophrenic and normal adults. Cognitive capacity was defined more broadly than on conventional intelligence tests and was assessed on tasks sensitive to aging in normal adults. In the paradigm adopted, four groups were compared--younger and older schizophrenics, and younger and older normal controls. The older subjects were individuals at least 60 years of age. In order to obtain groups with similar backgrounds, only veterans were used as subjects. The age of the younger subjects was determined by the age of World War II veterans at the time of testing, while the exact age of the two older groups was fixed by the age of World War I veterans. Since elderly schizophrenics were examined, all the schizophrenic subjects were necessarily chronic. The cognitive tasks administered consisted of dichotic listening, digit span, maze learning, verbal fluency, and the McGill Picture Anomaly Series. One psychomotor test--a tapping test--was also given. It was hypothesized that schizophrenics would generally perform more poorly than normal adults, and older subjects more poorly than younger ones on such measures as speed, accuracy, fluency and quickness to learn. What was not known was whether aging would have equally detrimental effects on the performance of normal and schizophrenic subjects. It was hoped that information concerning qualitative differences in cognition between schizophrenia and normal aging might be obtained from such measures as type of report on the dichotic listening task and instructional errors on the maze.

Method

Subjects

Eighty-four male veterans of the two World Wars served as subjects. There were four separate groups consisting of 21 elderly hospitalized chronic schizophrenic patients, 21 elderly normal subjects, 21 younger hospitalized chronic schizophrenic patients, and 21 younger normal subjects.

The older groups contained individuals over 60 with a mean age of 67.2 years. The younger groups contained individuals ranging in age from 35 to 49 years with a mean age of 43.4 years. An age difference of about 24 years separated the two age levels.

The normal subjects were all selected from patients being treated for minor medical ailments at a general hospital for veterans in Montreal, and all were discharged from hospital within two days of testing. Patients with histories of neurological or psychiatric disease were excluded from the sample.

The schizophrenic subjects in the study were drawn from a pool of English-speaking patients without lobotomies hospitalized in a chronic care hospital for veterans in St. Anne de Bellevue. Only those patients who had a consistent history of diagnosis of schizophrenia were admitted to the pool. The original pool, selected on this basis, consisted of 29 older and 30 younger patients almost all of whom had developed the disorder before 40 years of age. Since only 13 of these 59 patients had a diagnostic history with subtypal consistency, this factor was ignored in selection. Most of the schizophrenic patients in the final sample, however, would generally be considered nonparanoid. There was a consistent diagnosis in only 12 patients in the final sample--5 in the younger group and 7 in the older group--and in all these cases, the diagnosis was paranoid schizophrenia. Almost all the schizophrenic patients were receiving maintenance dosages of one of the phenothiazines. Drug therapy for these patients was not interrupted for testing.

The size of the groups in the final sample was restricted by the fact that only 21 of the 32 older schizophrenics tested completed all the tests in the battery. To equalize group size, testing in the other groups was discontinued as soon as 21 subjects were obtained who had completed all the tests. It was necessary to test only 24 of the 30 younger schizophrenics to produce a sample of 21. Thirty-five older normal subjects were tested to yield 21 subjects; there was no subject loss with the younger normal adults.

Most of the subject loss occurred on the stylus maze: seven normal subjects refused to complete it and testing of eight schizophrenics was terminated because of excessive time scores or inability to comprehend the instructions. One normal subject refused to take the dichotic listening task. Five normal subjects refused to return for the second test session, while two schizophrenics reported 24 hours late for it. One subject in each of the older groups was dropped because of suspected deafness in one ear detected during the dichotic listening task.

The four groups as finally constituted proved to be equivalent on years of schooling, an I.Q. measure prorated from the WAIS vocabulary subtest, and on the Wais digit span (forward) subtest (Wechsler, 1955). A description of the groups is provided in Table 1.

Table 1

Characteristics of Groups in the Final Sample

		Schizophrenics		Controls	
		Younger	Older	Younger	Older
Age in years	Mean	43.3	67.2	43.5	67.2
	S.D.	3.1	4.6	3.1	4.0
	Range	35-49	60-75	36-49	60-76
WAIS Vocabulary I.Q.	Mean	108.1	112.9	111.9	119.3
	S.D.	15.9	17.9	16.8	9.7
	Range	76-134	83-142	90-143	90-140
WAIS Forward Digit-Span	Mean	6.4	6.0	6.4	6.1
	S.D.	1.5	1.2	1.3	1.1
	Range	4-9	4-9	4-8	4-9
Years of Education	Mean	8.0	8.1	8.1	7.9
	S.D.	2.4	3.3	2.0	2.7
	Range	5-15	4-15	4-13	3-15
Length of present hospitalization in years	Mean	9.8	21.6		
	S.D.	5.2	13.2		
	Range	2-20	2-45		
Age of onset of pathology in years	Mean	27.1	33.1		
	S.D.	4.9	5.1		
	Range	19-38	24-41		

Note.-Each group contained 21 subjects

Procedure

There were two test sessions 24 hours apart. Each subject was given the WAIS vocabulary and forward digit-span subtests at the beginning of the first session. The following tasks were then administered in the order named: First Session: an oral verbal fluency test, the McGill Picture Anomaly Series (M), and a stepping-stone maze learning task;

Second Session: stepping-stone maze relearning, a tapping test, a dichotic listening task, and a digit-span power test.

Although counterbalancing was used within parts of tests when appropriate, the order in which the different tests were administered was fixed. Two considerations led to the decision to use an invariant order. The different amounts of time needed to administer the tests made is impossible to use all combinations of tests in any one session. Moreover, the maze learning and retention test had to occupy fixed positions at the end of the first test session and the beginning of the second.

Specific procedures for individual tests are described in the order in which they were carried out.

Verbal Fluency Test

The verbal fluency test had two parts: animal naming, in which the subject was asked to name as many animals as he could in one minute; and word naming, in which he was asked to say as many words as he could in one minute. The order of presentation of the two parts of the test was alternated for subjects within groups. The score for each part was simply the number of different words produced in each category. If the same word was given in both parts of the test, it was counted as a response on both occasions.

McGill Picture Anomaly Series (M)

The McGill Picture Anomaly Series (M) consists of 12 practice and 30 test pictures each containing an incongruity. Each subject was simply told to point out what was funny or out of place and was given as much time as he needed on each picture. Trials with the 12 practice stimuli were immediately followed by trials with the 30 test pictures. Two scores were obtained for each subject: the time required to complete the test and the number of incongruities correctly identified.

Stepping-Stone Maze: Learning and Retention

The maze employed was a modified version of the stepping-stone maze described by Barker (1931). Diagrams of the upper surface and the wiring are provided in Appendix I. The maze consisted of a 13-in. square of ½-in. plywood painted black. One hundred 1½-in. (10-32) flat-headed machine screws were spaced in the wood 1 in. apart in a 10 x 10 array and fixed so that their heads were level with the surface. The upper surface of the maze looked homogenous except for the starting point and the goal which were labelled. The correct path, which was that used by Milner (1965), proceeded by 28 steps from the starting point in the lower left corner to the goal in the upper right and required two turns away from the goal. The shanks of the screws projected 1 in. beneath the maze proper and served as supports for it. Shanks of screws not included in the correct path were wired in series and placed in circuit with a 5-in. metal-tipped stylus and an automatic counter so that the circuit was completed when any of the incorrect points was touched with the stylus. Completion of the circuit activated the counter with a loud click.

The subject was instructed to discover and learn the correct path by tapping from one bolthead to the next with the stylus. He was told that when he heard a click, it indicated that an error had been made and that he was to go back to the preceding bolthead. He was also told that he was not to retrace the correct path nor to move diagonally across the board.

A trial consisted of one complete tracing of the correct route through the maze from the starting point to the goal. For both the maze acquisition task, given at the end of the first session, and the 24-hour retention test, given at the beginning of the second session, the subject was required to learn the correct path to a criterion of two consecutive errorless trials. A total error count per trial was provided by the automatic counter; a manual record was also kept of the incidence of four different kinds of errors on each trial. Three of the errors represented failure to follow instructions: retracing errors, diagonal errors, and no-return errors (failure to return to the preceding correct bolthead after an error). In addition, any repetition of a mistake that was not a failure to follow instructions was recorded as a repeated error. The time required to complete each trial was also recorded.

The scores obtained for each subject were: number of trials to criterion for both initial acquisition and relearning of the maze; mean latency per criterion trial for both initial acquisition and maze relearning; number of retracing, diagonal, no-return, and repeated errors for each maze session; and total errors on the initial relearning trial.

Tapping Test

The equipment used for the tapping test consisted of the same metal stylus and automatic counter used for the maze task, and a 6½ x 5½-in. metal plate divided lengthwise by a strip of wood-moulding ½-in. wide. The metal plate was placed in circuit with the stylus and counter so that a tap on the plate with the stylus completed the circuit and was recorded automatically by the counter.

The subject was required to tap back and forth across the moulding as quickly as he could. He was first given two 10-sec. practice trials and then three blocks of three 10-sec. experimental trials. The trial blocks were separated by a rest interval of approximately 10 sec.; the intertrial interval was approximately 5 sec. The score used was the mean number of taps for each three-trial block.

Dichotic Listening Task

The equipment used for the dichotic listening task consisted of a stereophonic tape recorder (Uher Model SR 1) and stereophonic headphones (Dynamic Headphones, AKG, K - 50). In accordance with standard procedure for dichotic presentation, pairs of digits were recorded on both channels of the tape recorder in such a way that when played back one number arrived at one ear simultaneously with a different number arriving at the other ear. Only numbers from 1 to 10 were used and all were recorded in the same male voice.

In addition to 13 1-pair series used for practice, there were 90 test series recorded in nine blocks of 10 series each (Appendix II) with a 10-sec. interseries interval. The blocks constituted the nine different conditions produced by recording each of three different lengths of series (2-, 3-, and 4-pair) at each of three speeds (fast: 1 pair/½ sec.; medium: 1 pair/1 sec.; and slow: 1 pair/2 sec.). In the 2- and 3-pair series, numbers were never repeated within any given series. In the 4-pair series, numbers were occasionally used twice in the same series; when this was the case, the repeated number was always presented in the same channel.

Three fixed orders of presentation were used in which the three blocks of any given series length were administered before another series length was given. For two of the orders, the 2-, 3-, and 4-pair material was presented in order of increasing length. In the first order, the series within a given length were presented beginning with the fast presentation rate and ending with the slow, and in the second order, beginning with the slow and ending with the fast. For the third order, the material was presented in blocks of decreasing series length starting with the 4-pair and ending with the 2-pair material; the presentation rates were always administered from fast to slow.

Each of the four experimental groups was divided into three subgroups of seven subjects equated on WAIS forward digit-span, WAIS vocabulary I.Q., age, and performance on the practice series. Within the experimental groups, each subgroup was given one of the three fixed orders of presentation. The ear to which the stimuli on a given channel were presented was alternated for subjects within the experimental subgroups.

The subject was first told that he would hear two numbers together, one in each ear, and that he was to report what he heard in any order. He was then given three practice series of one pair each. If he failed to respond or gave the wrong number in any of these three series, the volume in the incorrect channel was increased until the correct response was made. The subject was then given 10 additional practice series of one pair each. After each response, he was asked whether the volume in the two ears felt equally loud; if not, appropriate adjustments in volume were made to equate the sound in the two ears. The practice series served to ensure that any hearing losses in the older subjects would not alter the order of their verbal reports.

At the beginning of the test series the subject was instructed to report, in any order, as many of the numbers from both ears as he could remember. At the beginning of each series of a new length, he was told how many pairs he would hear.

Two major response measures (adapted from Bryden, 1962) were used for each condition: accuracy of report and order of report. Accuracy of report referred to the number of digits correctly reported regardless of the order of report, and without correction for guessing. Report order was labelled <u>ear order</u> when all the digits in one channel were reported before any from the other channel, <u>temporal order</u> when the digit pairs were reported in the order of their arrival at the ear, and <u>miscellaneous</u> for any other system of reporting.

Digit-Span Power Test

The equipment used for recording and playing back the stimuli for this test consisted of the same stereophonic tape recorder and headphones employed for the dichotic listening task.

The stimuli consisted of 48 random number series which varied in length from 2 to 9 digits and which employed only arrangements of the numbers from 1 to 10. The series were divided into three blocks of 16 with each block constituting a 16-trial digit-span test (see Appendix III). The series in each block were arranged in order of increasing length, beginning with 2-, and ending with 9-digit series, with each of the possible lengths from 2 to 9 digits represented twice. The blocks were each recorded at a different speed in order to provide tests of digit-span capacity under three different presentation rates: 1 digit/½ sec., 1 digit/1 sec., and 1 digit/2 sec. An interseries interval of approximately 10 sec. was used in each test. The order of presentation of the three tests was randomized within each of the experimental groups.

The series were presented binaurally to the subject through headphones. He was asked to report the numbers in the order in which he heard them. Testing at each presentation rate was continued until the subject failed both trials at a given difficulty level. There was an interval between digit-span tests of approximately 3 min. The score for each test was the number of digits in the last correctly reported series.

Results

Separate analyses of variance were carried out on the scores resulting from each task. Although the analysis of variance design appropriate for the situation varied from task to task, the main effects for each analysis always included the two variables, pathology and age. The tables of analyses of variance are given in Appendix IV, and the relevant means and standard deviations, in Appendix V. Because F max tests for homogeneity of variance revealed significant differences in within cell variances, raw scores on a number of the measures were converted into log scores before analysis. Scheffé's multiple comparison procedure (Edwards, 1968, p. 150) was used when necessary to compare group means following significant main effects and interactions.

Verbal Fluency Test

A three-factor analysis of variance with repeated measures for the two parts of the fluency test was carried out on log scores. The analysis revealed three significant main effects and no significant interactions. The mean number of words produced by the schizophrenic groups in one minute was 14.9 and by the normal groups, 18.0. This difference was significant [$F\ (1, 80) = 8.66$, $p < .005$]. The effect of age was also significant [$F\ (1, 80) = 4.82$, $p < .05$], with older subjects giving fewer words (15.1) than younger ones (17.9).

Constraint significantly affected the number of words produced [$F\ (1, 80) = 19.11$, $p < .001$]. The mean number of words given was 18.1 when subjects were free to give any word they chose, but only 14.9 when they were restricted to the animal category.

McGill Picture Anomaly Series (M)

Two-factor analyses of variance as a function of pathology and age were carried out for both the number of anomalies correctly identified and the time taken to complete the test. Each analysis revealed significant main effects for pathology and age, but no interaction between them.

Schizophrenics correctly identified a mean of only 19.6 anomalies, while normal subjects correctly identified 23.6 [F (1, 80) = 17.40, $p < .001$]. Older subjects made on the average 19.8 correct responses and younger ones, 23.4. This difference was also significant at the .001 level [F (1, 80) = 13.55].

Schizophrenics required more time to complete the task than the normal subjects [F (1, 80) = 15.99, $p < .001$]; the group means were 12.6 and 9.4 sec., respectively. Older subjects also required more time than younger subjects [F (1, 80) = 14.32, $p < .001$]; the group means were 12.5 and 9.5 sec., respectively.

Stepping-Stone Maze

Trials to criterion

A three-factor analysis of variance of log trials-to-criterion scores was carried out as a function of pathology and age, with repeated measures for test sessions. As might be expected, substantial savings were demonstrated on the relearning session. The mean number of trials to criterion for all subjects decreased from 39.8 on the first session to 13.4 on the second [F (1, 80) = 373.78, $p < .001$]. There were no significant interactions between test session and either pathology or age.

Significant main effects were obtained for pathology [F (1, 80) =

12.46, $p < .001$], and age [$F(1, 80) = 30.33$, $p < .001$]; and in addition there was a significant Pathology x Age interaction [$F(1, 80) = 8.55$, $p < .005$], which is shown in Figure 1. The main effects indicated that schizophrenics took longer to reach criterion than normal subjects, and older subjects longer than younger ones. Tests of the significant interaction, however, indicated that the effect of age was much more pronounced for the normal ($p < .001$), than for the schizophrenic groups ($p < .10$); and that the pathology effect resulted from a marked superiority of the younger normal over the younger schizophrenic subjects ($p < .001$), there being no significant difference between the two older groups. The mean number of trials to criterion for the combined test sessions was 33.3 for the older schizophrenics, 27.7 for the younger schizophrenics, 31.9 for the older normal subjects, and 13.5 for the younger normal subjects.

Instructional Errors

A three-factor analysis of variance of instructional errors as a function of pathology and age, with repeated measures for error type, was carried out on log transformed scores. The transformation used was $X' = \log (X + 1)$, since some of the error scores were equal to or close to zero. Because so few subjects made instructional errors on the second maze session, only errors made during the initial acquisition session were analysed.

In addition to significant main effects for pathology [$F(1, 80) = 24.82$, $p < .001$] and age [$F(1, 80) = 6.77$, $p < .025$], there was a significant Pathology x Age interaction [$F(1, 80) = 8.36$, $p < .005$] which is shown in Figure 2. The main effects indicated that schizophrenics tended to make more errors than normal subjects, and older subjects more errors

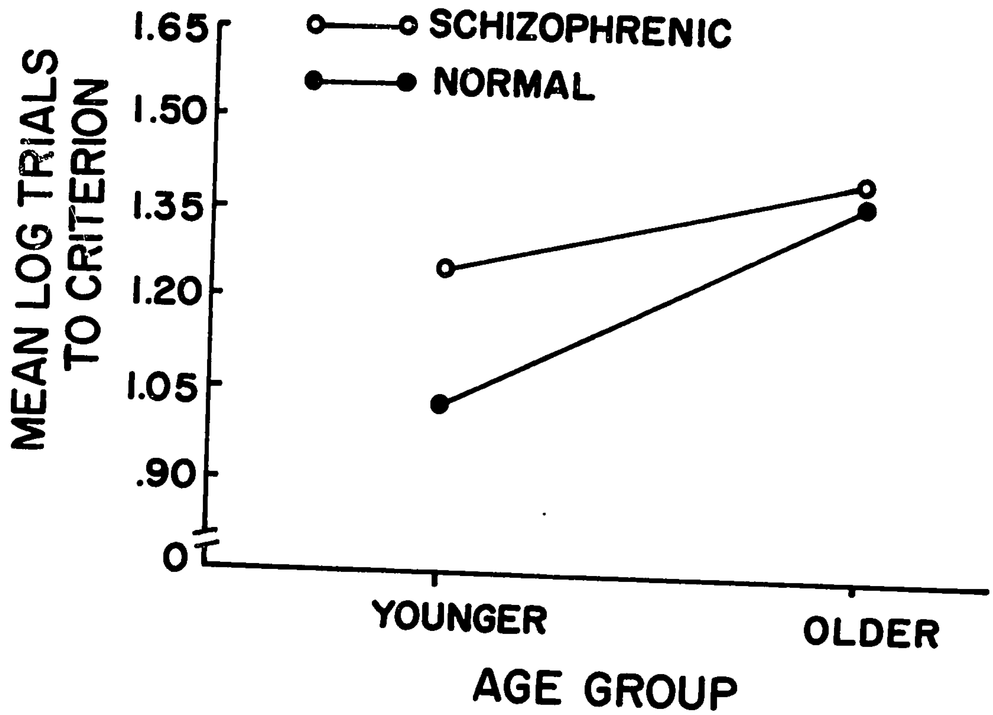

Fig. 1. Stepping-stone maze: interaction between pathology and age for trials to criterion on the combined test sessions.

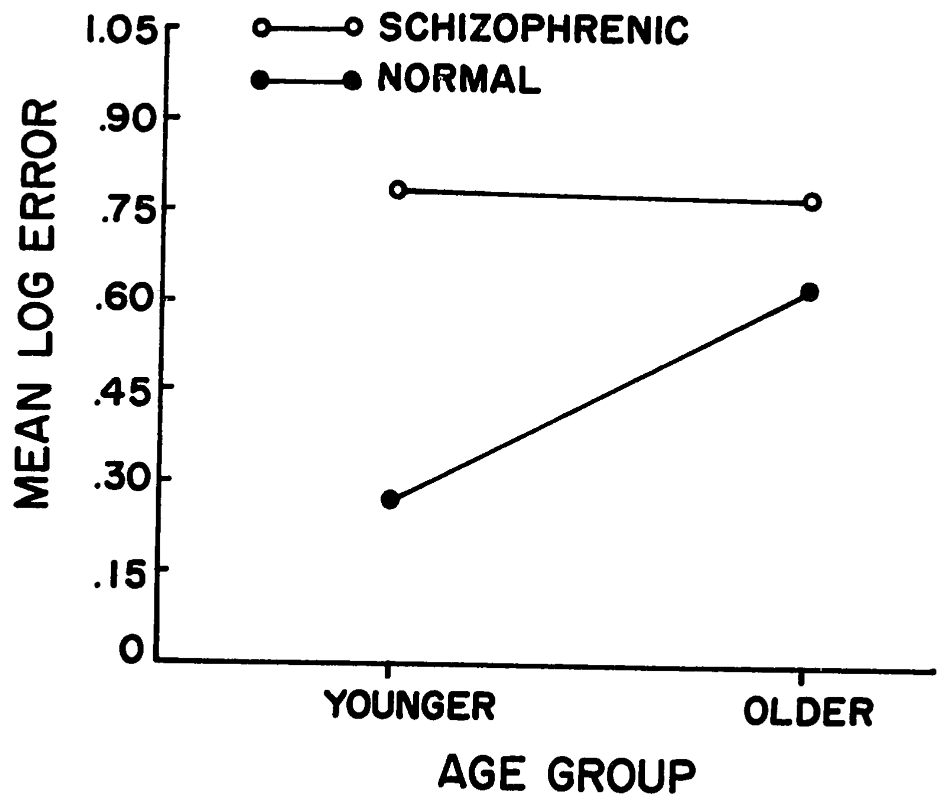

Fig. 2. Stepping-stone maze: interaction between pathology and age for instructional errors.

than younger ones. The interaction, however, reflected the fact that the pathology effect was mainly the result of a difference between the two younger groups of subjects ($p < .001$), the difference between the older groups being significant only at the .10 level; and that the age effect was solely attributable to a difference between older and younger normal subjects ($p < .001$), with the schizophrenic groups, in fact, showing a nonsignificant tendency for errors to decrease with age. The mean number of instructional errors was 7.6 for the older, and 10.1 for the younger schizophrenic groups; and 6.6 for the older, and 1.4 for the younger normal groups.

The number of instructional errors were not distributed equally among the three rules [$F(2, 160) = 81.47$, $p < .001$]. Subjects tended to make far more retracing and no-return errors than diagonal ones. The mean number of errors of each type was 9.5, 7.2, and 2.4, respectively. The analysis of variance also showed a significant Age x Type of Instructional Error [$F(2, 160) = 3.79$, $p < .025$] and a significant Pathology x Age x Type of Instructional Error interaction [$F(2, 160) = 6.53$, $p < .005$]. The triple interaction is shown in Figure 3. In general, although the pattern of error distribution was similar for all groups, there was relatively less difference in the incidence of the different type of instructional errors for the younger normal subjects. In addition, the older normal group obtained high retracing and no-return error scores like the two schizophrenic groups, but resembled the younger normal subjects in their low incidence of diagonal errors.

Repeated Errors

A two-factor analysis of variance of repeated errors as a function

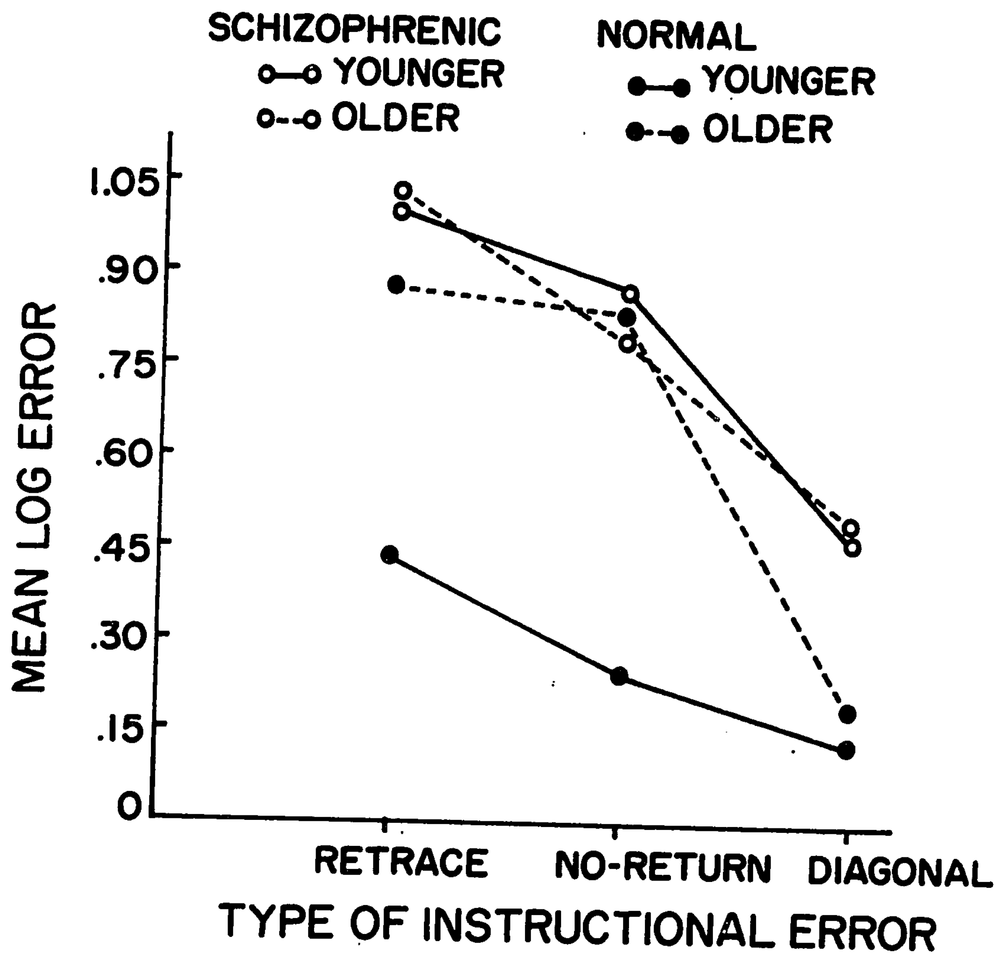

Fig. 3. Stepping-stone maze: interaction of pathology, age, and type of instructional error.

of age and pathology was carried out on log (X + 1) scores. As in the case of instructional errors, only repeated errors made on the initial acquisition session were included in the analysis. The analysis yielded a significant main effect of pathology [$F(1, 80) = 30.81$, $p < .001$] but not of age, and a significant Pathology x Age interaction [$F(1, 80) = 7.19$, $p < .01$] shown in Figure 4. Tests of the interaction revealed effects like those obtained in the trials-to-criterion and instructional errors analysis. The significant main effect of pathology, which indicated that schizophrenics made more errors than normal subjects, was essentially the result of a marked difference between the two younger groups ($p < .001$), since the slight difference between the scores of the older groups was not significant. Moreover, an age difference was obtained for the normal groups which showed that older normal subjects made significantly more errors than younger ones ($p < .05$). The mean number of repeated errors was 9.3 for the older schizophrenics, 15.4 for the younger schizophrenics, 8.9 for the older normal subjects, and 1.5 for the younger normal subjects.

Mean Latency per Criterion Trial

A three-factor analysis of variance as a function of pathology and age, with repeated measures for test sessions was carried out on the mean time to complete the two criterion trials. The mean latency per criterion trial for the first session was 27.2 sec. and for the second session, 26.8 sec. This difference was not significant. Although schizophrenics took 4.3 sec. longer than normal subjects to tap out the path, this difference was also not significant. On the other hand, older subjects took significantly longer than younger subjects to complete the criterion trials [$F(1, 80) = 9.34$, $p < .005$]. The mean latency for the

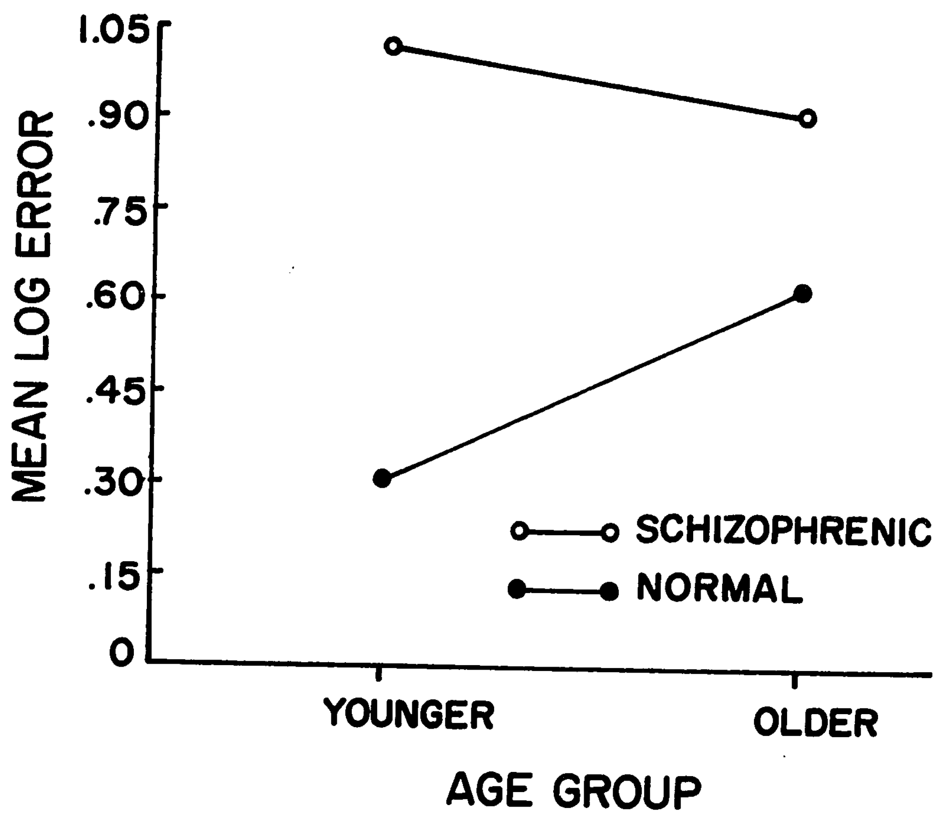

Fig. 4. Stepping-stone maze: interaction between pathology and age for repeated errors.

older group was 59.2 sec. and for the younger group, 47.9 sec. None of the interactions was significant.

Errors on Initial Relearning Trial

A two-factor analysis of variance of the total number of errors made on the first maze relearning trial was carried out to determine whether differences in memory loss attributable to either pathology and/or age were apparent after 24 hours. The mistakes made in almost all cases were single unrepeated errors. Although schizophrenics made on the average 5.7 errors and normal subjects, only 4.6, the effect of pathology was not significant. There was, however, a significant age effect [$F\ (1, 80) = 5.80,\ p < .025$]. More errors were made by the older subjects (5.9) than by the younger ones (4.4).

Tapping Test

A three-factor analysis of variance of tapping scores as a function of pathology and age, with repeated measures for trial block, was carried out. Schizophrenic subjects tapped more slowly than normal subjects. The mean tapping rates per 10-sec. were 40.0 and 47.1 respectively [$F\ (1, 80) = 27.96,\ p < .001$]. Older subjects tapped slower than younger ones [$F\ (1, 80) = 5.15,\ p < .05$]. The mean tapping rates per 10-sec. were 42.1 and 45.1 respectively. All subjects tapped progressively faster with practice [$F\ (2, 160) = 10.05,\ p < .001$]. The mean tapping rates per 10-sec. increased from 42.8, to 43.8, and finally to 44.0 over the three blocks of trials. There were no significant interactions.

Dichotic Listening Task

Four-factor analyses of variance as a function of pathology and age with repeated measures for amount of material and presentation rate were carried out on frequency of ear order report, frequency of temporal order report, and percentage of digits correctly reported. It should be kept in mind that, while frequency of ear and temporal order report were not completely independent, these two measures need not necessarily bear a converse relation to each other, since reports could also be classified as miscellaneous. The relative frequency of each kind of report is given in Table 2.

Table 2

Relative Frequency (in per cent) of Report Classes

Classification	Schizophrenics		Controls	
	Younger	Older	Younger	Older
Ear	40.1	46.9	22.9	27.3
Temporal	37.8	29.5	50.9	47.3
Miscellaneous	22.1	23.6	26.2	25.4

Ear Order Report

Schizophrenic subjects used ear order report more frequently than normal subjects [F (1, 80) = 15.16, $p < .001$]. The average number of ear order reports per 10-trial block made by the schizophrenics was 4.3 and by the normal subjects only 2.5. The mean number of ear order reports made by the older subjects was 3.7 and by the younger ones, 3.2. This difference was not significant.

Increasing the amount of material in a series resulted in a decrease in the frequency of ear order report [F (2, 160) = 33.29, $p < .001$]. The mean number of ear order reports decreased from 4.2 for the 2-pair series to 3.6 for the 3-pair series and then to 2.5 for the 4-pair series. There was a significant Pathology x Amount of Material interaction [F (2, 160) = 5.47, $p < .005$] which is shown in Figure 5. While both schizophrenic and normal subjects used less ear order report with 4-pair than with 2-pair series ($p < .001$ in each case), increasing the amount of material in a series from 2- to 3-pairs did not affect the use of ear order report by the normal subjects, but did result in a reduction in its use by the schizophrenics ($p < .001$).

The analysis also showed that the slower the presentation rate, the less use was made of ear order report [F (2, 160) = 94.13, $p < .001$]; the mean number of ear order reports decreased from 4.8 at the fast speed, to 3.4 at the medium speed, and then to 2.1 at the slow speed. There was a significant Amount of Material x Presentation Rate interaction [F (4, 320) = 3.57, $p < .01$] which is shown in Figure 6. The interaction reflected the fact that only the 2-pair series were systematically affected by each change in presentation rate ($p < .001$ for each comparison). While there was significantly less use of ear order report for both the 3- and 4-pair series under the slow than under the fast presentation rate condition ($p < .001$ for both comparisons), there was no significant difference for the 3-pair series between the fast and medium presentation rates, and for the 4-pair series between the medium and slow presentation rates.

Temporal Order Report

The schizophrenics used temporal order report less frequently than the normal subjects [F (1, 80) = 10.68, $p < .005$]. The mean number

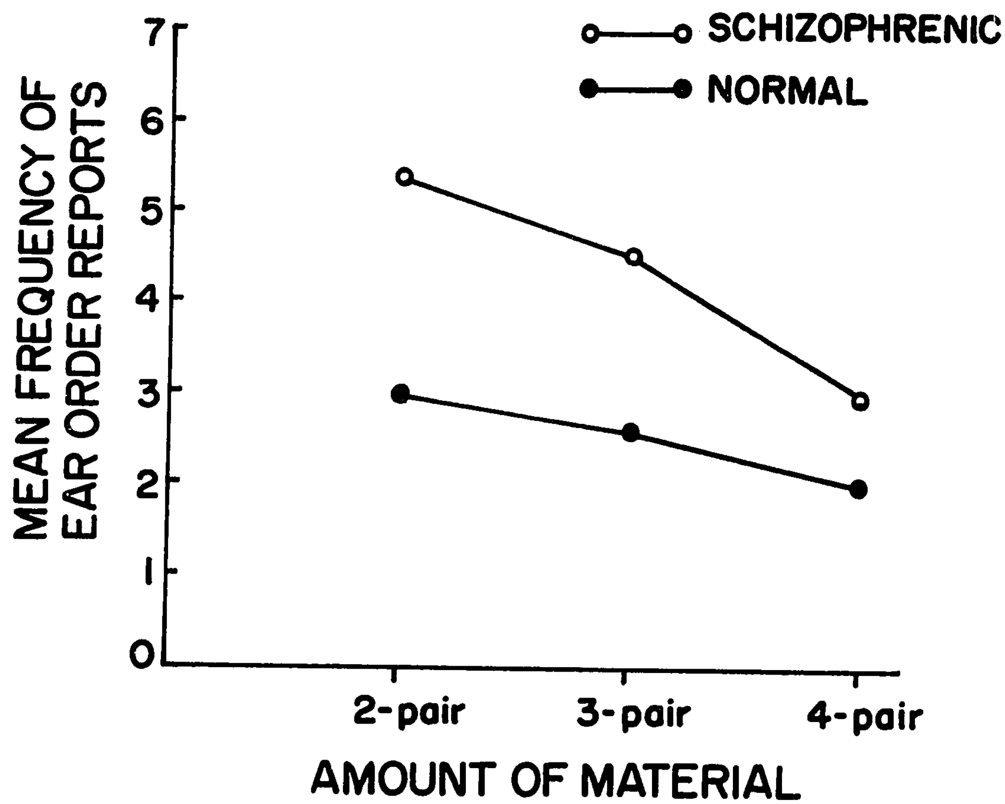

Fig. 5. Dichotic listening task: interaction between pathology and amount of material for ear order report.

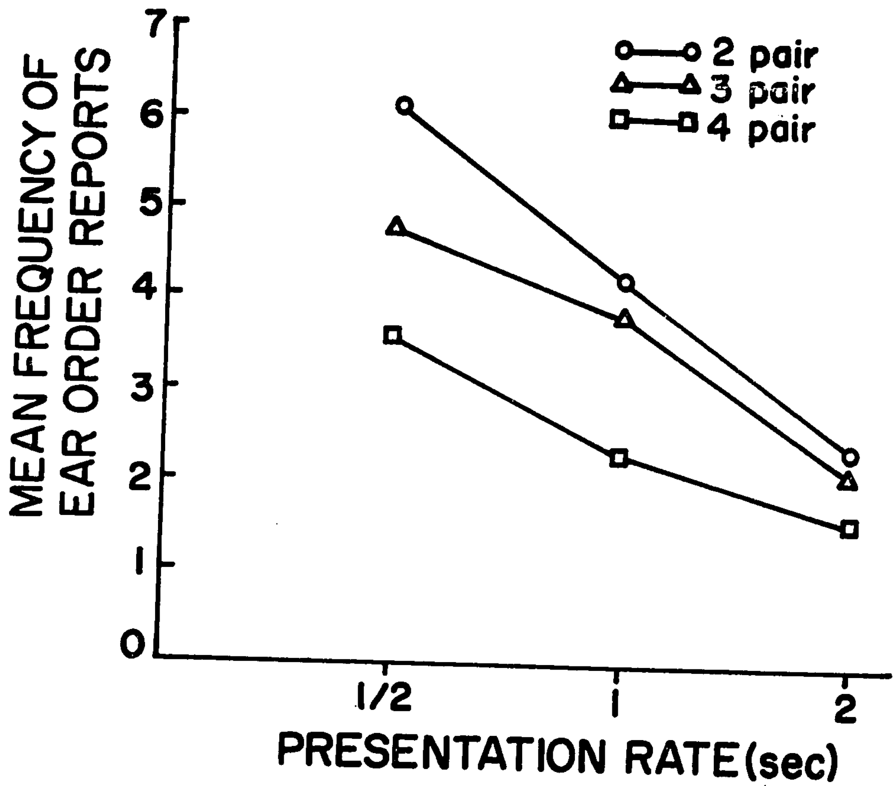

Fig. 6. Dichotic listening task: interaction between amount of material and presentation rate for ear order report.

of such reports per 10-trial block was 3.3 for the schizophrenic groups and 4.9 for the normal groups. Older subjects used temporal order report on an average of 3.8 occasions per 10-trial block, and younger ones, 4.4. The effect of age, however, was not significant.

Increasing the amount of material in a series resulted in a decrease in the use of temporal order report [$F(2, 160) = 19.74$, $p < .001$]. A significant Pathology x Amount of Material interaction [$F(2, 160) = 15.79$, $p < .001$], shown in Figure 7, indicated that the main effect of amount of material was attributable solely to the performance of the normal subjects. Their frequency of temporal order report declined from 6.3 for 2 pairs, to 5.1 for 3 pairs, and finally to 3.4 for 4 pairs ($p < .001$ in each case), while the frqeuency of temporal order report for the schizophrenics was 3.6 for 2 pairs, 3.1 for 3 pairs, and 3.4 for 4 pairs.

The main effect of presentation rate was also significant [$F(2, 160) = 79.20$, $p < .001$]. The slower the presentation rate, the more subjects tended to report the series in temporal order; the mean frequency of temporal order reports increased from 2.8 at the fast speed, to 4.1 at the medium speed, and then to 5.5 at the slow speed. There was, however, a significant Amount of Material x Presentation Rate interaction [$F(4, 320) = 12.68$, $p < .001$], which is shown in Figure 8. The interaction resulted from the fact that the frequency of temporal order reports was significantly different at each presentation rate for both the 2- and 3-pair series, while for the 4-pair series, only the difference between the fast and slow presentation rates was significant. A significant Age x Amount of Material x Presentation Rate interaction [$F(4, 320) =$

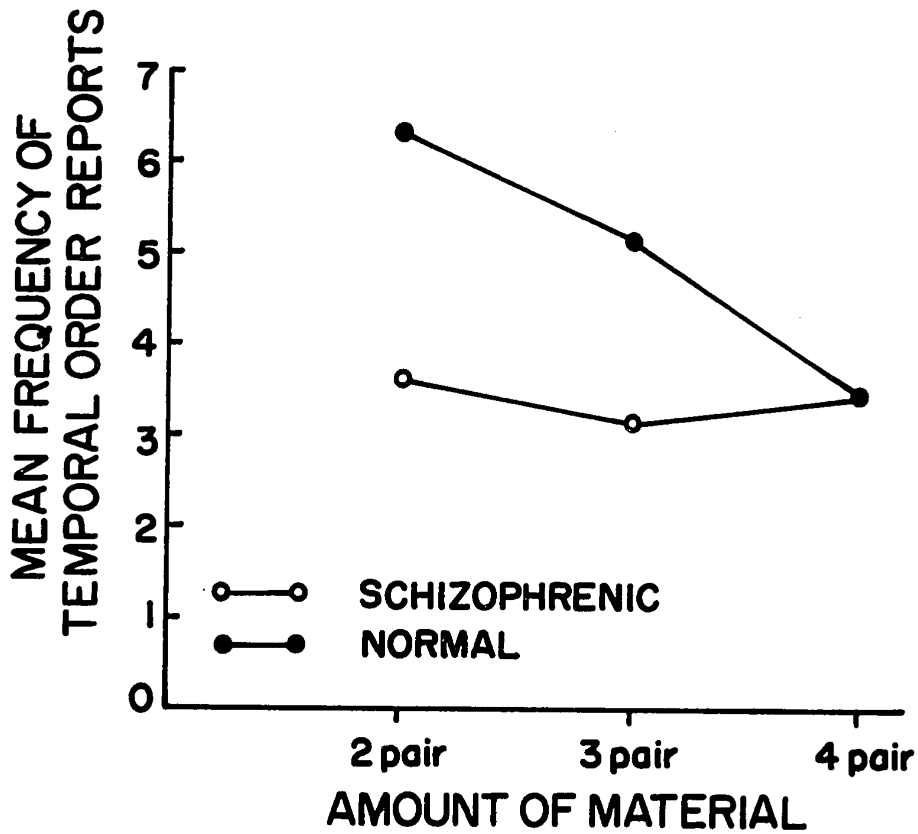

Fig. 7. Dichotic listening task: interaction between pathology and amount of material for temporal report.

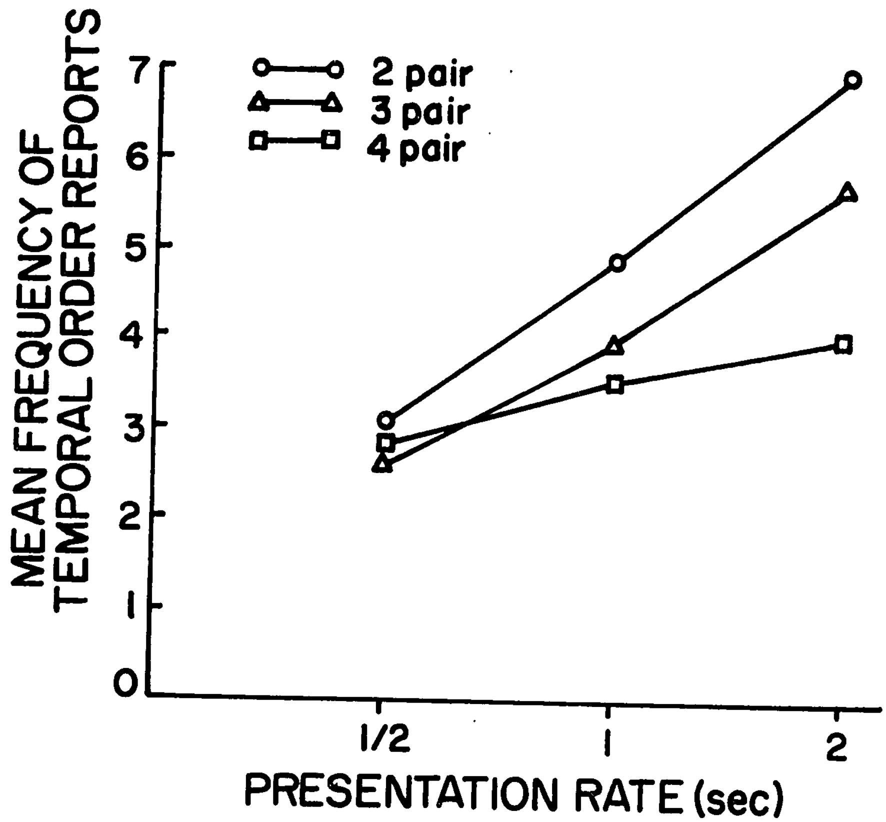

Fig. 8. Dichotic listening task: interaction between amount of material and presentation rate for temporal order report.

2.75, $p < .05$] which was also found, simply reflected the fact that the increase in use of temporal reports seen for the 2-pair series from fast to medium speed and for the 3-pair series from medium to slow speed, was the result of changes in the performance of the younger subjects (see Figure 9).

Accuracy of Report

Significant main effects were obtained for both pathology [$F\ (1, 80) = 10.49$, $p < .005$] and age [$F\ (1, 80) = 5.32$, $p < .025$]. Schizophrenics correctly reported fewer digits than normal subjects; the mean per cent correct was 80.4 for the schizophrenic subjects and 85.2 for the normal subjects. Older subjects correctly reported fewer digits than younger ones; the mean per cent correct was 81.1 for the older subjects and 84.5 for the younger ones.

The analysis showed that the shorter the series, the better was the accuracy of report [$F\ (2, 160) = 704.86$, $p < .001$]. The percentage of digits correctly reported was 93.8 for the 2-pair series, 83.9 for the 3-pair series, and 70.7 for the 4-pair series. A significant Pathology x Amount of Material interaction [$F\ (2, 160) = 4.74$, $p < .01$], shown in Figure 10, was caused by the fact that the schizophrenic subjects showed a relatively greater loss in accuracy with each increase in amount of material than the normal groups.

The analysis also showed that the slower the presentation rate, the better the accuracy of report [$F\ (2, 160) = 32.23$, $p < .001$]. The mean percentage of digits correctly reported was 84.9 at the slow speed, 82.4 at the medium speed, and 81.0 at the fast speed. A significant Pathology x Presentation Rate interaction was also found [$F\ (2, 160) = 6.25$, $p < .005$].

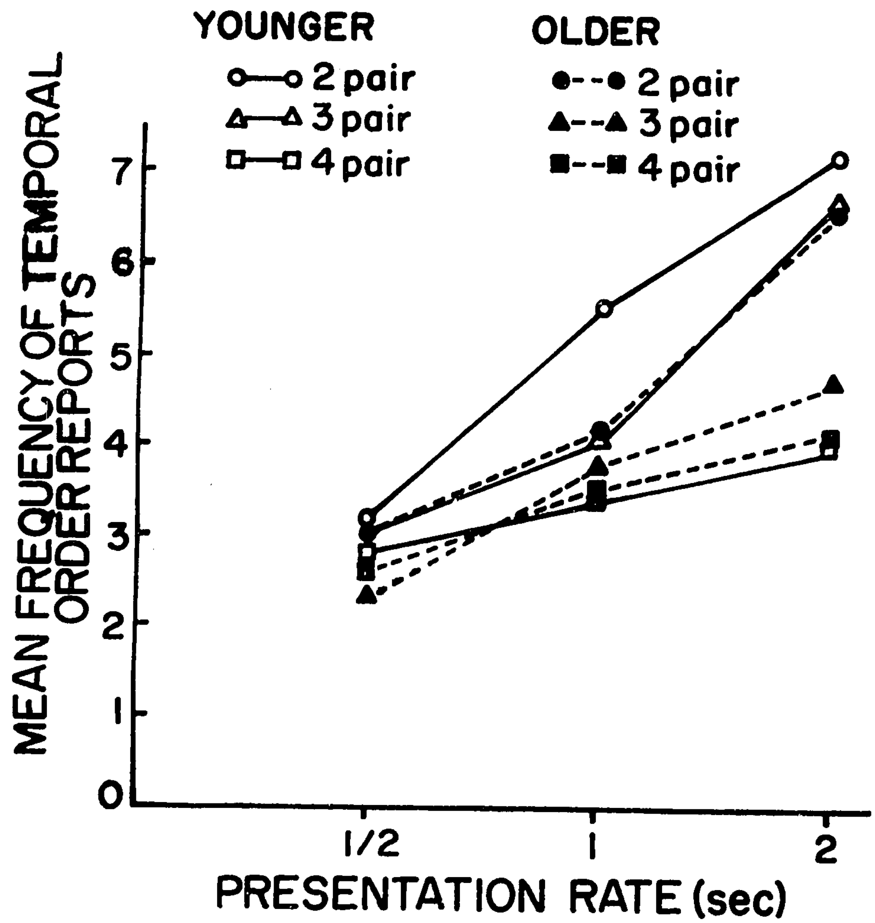

Fig. 9. Dichotic listening task: interaction of age, amount of material, and presentation rate for temporal order report.

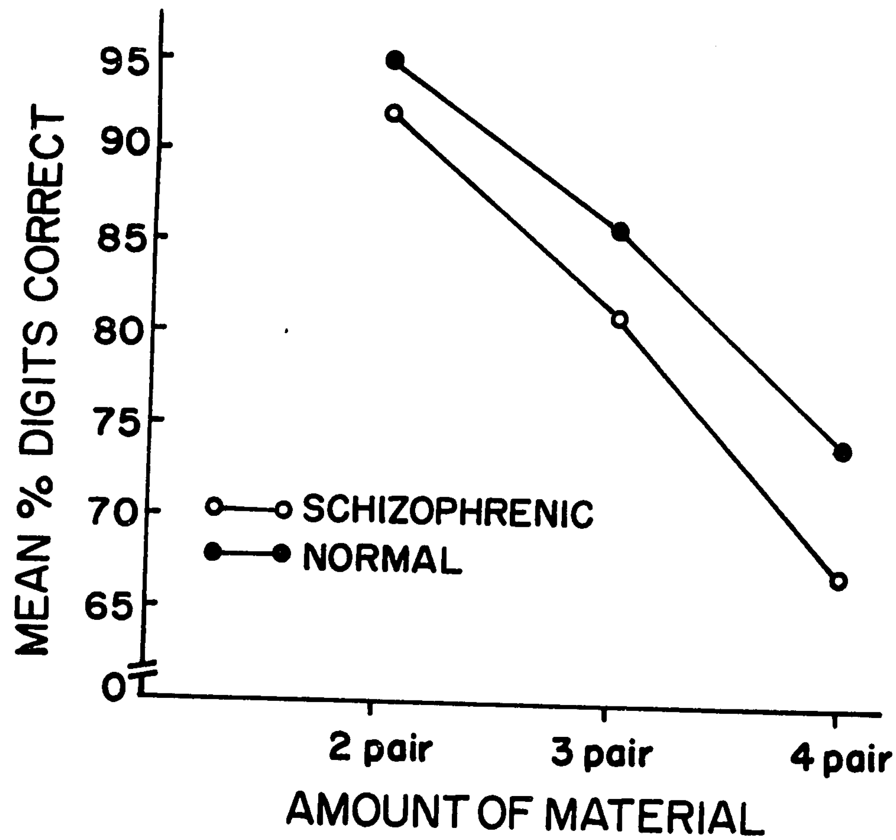

Fig. 10. Dichotic listening task: interaction between pathology and amount of material for accuracy of report.

It was caused by the fact that the performance of the normal subjects was much more affected by each change in presentation rate than was that of the schizophrenics. For the combined normal groups, the differences between accuracy at each presentation rate were all significant at the .001 level. For the combined schizophrenic groups, on the other hand, although accuracy was better at the slow than at either the fast ($p < .001$), or the medium ($p < .05$) speeds, it did not differ at the fast and medium speeds. A weak but significant Pathology x Age x Presentation Rate interaction was also obtained [$F (2, 160) = 3.42$, $p < .05$] which is shown in Figure 11. This interaction chiefly reflected the fact that the accuracy of report of the older shcizophrenics, but not the younger ones, was unaffected by changes in presentation rate.

A significant Amount of Material x Presentation Rate interaction was also found [$F (4, 320) = 4.46$, $p < .005$]. For the 3- and 4-pair series, the relation between accuracy and presentation rate was the same as that for the main effect; that is, the slower the presentation rate, the better the accuracy of report. On the other hand, for the 2-pair series, not only was the difference between the fast and slow speeds nonsignificant, but there was also a slight drop in accuracy at the medium speed. There was, however, a significant Pathology x Amount of Material x Presentation Rate interaction [$F (4, 320) = 3.19$, $p < .025$] which is shown in Figure 12. In general the rate of change in accuracy for 2- and 4-pair series was similar for both the schizophrenic and normal subjects. This interaction was mainly caused by differences between the performance of the schizophrenic and normal subjects on the 3-pair series. Thus, for the 3-pair series, while the accuracy of the combined normal groups improved with

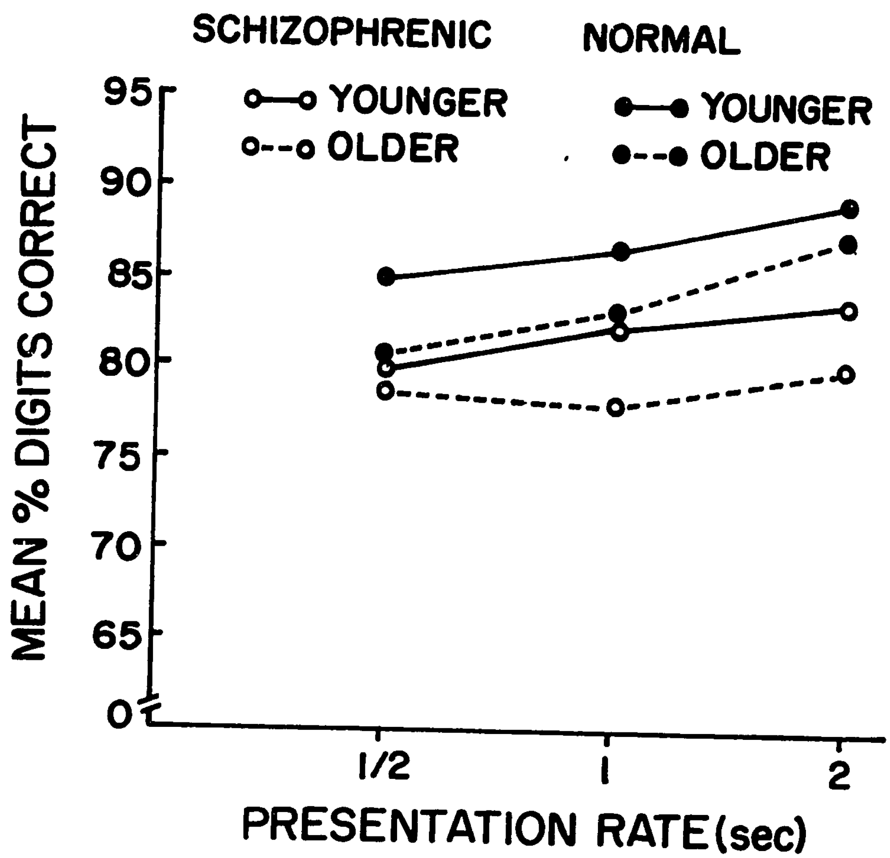

Fig. 11. Dichotic listening task: interaction of pathology, age, and presentation rate for accuracy of report.

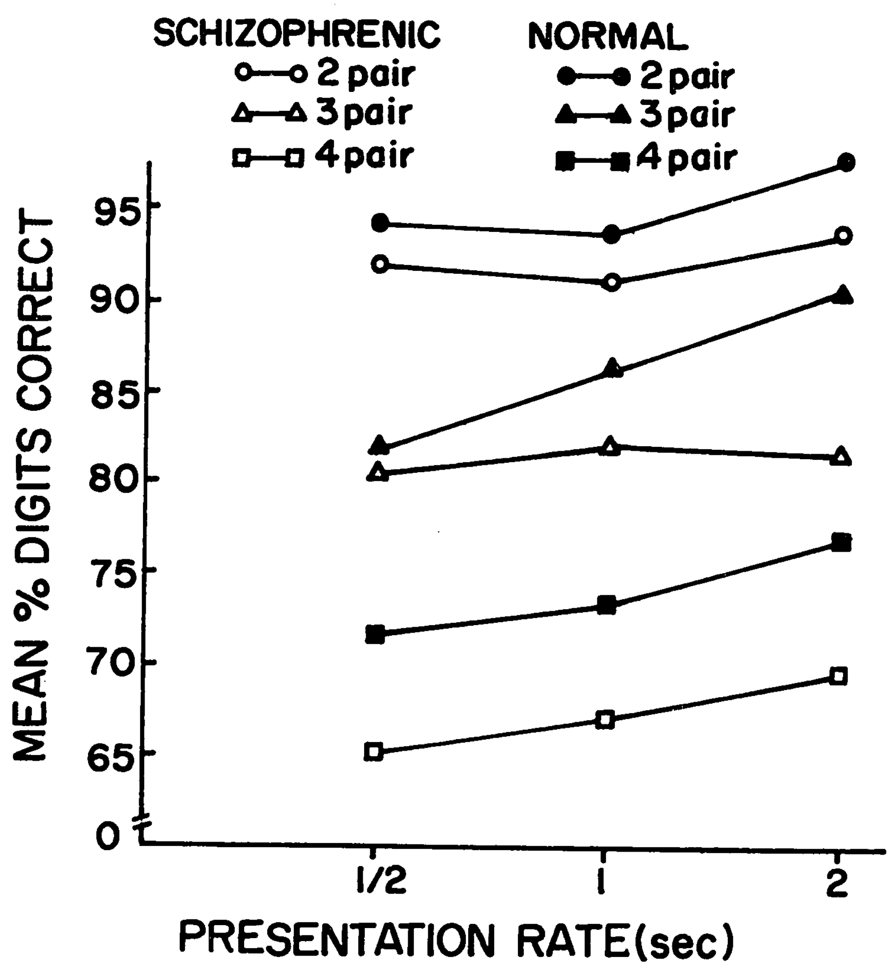

Fig. 12. Dichotic listening task: interaction of pathology, amount of material, and presentation rate for accuracy of report.

each change in presentation rate and was actually significantly better at the fast than at the slow speed ($p < .001$), the accuracy of the combined schizophrenic groups was similar for all presentation rates. This resulted in nonsignificant differences between the two combined groups at the fast and medium speeds, but at the slow speed the normal subjects correctly reported significantly more digits ($p < .001$) than the schizophrenics.

Digit-Span Power Test

A three-factor analysis of variance of digit span-scores was carried out as a function of pathology and age, with repeated measures for presentation rate. The only significant effect obtained was for presentation rate [$F\ (2, 160) = 3.17$, $p < .05$]. All subjects recalled more digits at the fast presentation rate, than at the slow ($p < .05$). The mean number of digits recalled was 6.1 at the ½-sec. rate, 5.9 at the 1-sec. rate, and 5.7 at the 2-sec. rate. There was no difference between the schizophrenic (5.9 digits) and normal subjects (6.0 digits) or between older subjects (5.9 digits) and younger ones (6.0 digits). There were no significant interactions.

Discussion

In the present investigation several tasks were employed to assess differences in cognitive capacity between schizophrenic and normal adults as a function of age. A discussion of the results for each of these tasks will follow. It is important to note first, however, that the results yielded no evidence for a progressive loss of functioning in schizophrenia. This is especially significant since all the schizophrenics studied had histories of long hospitalization and had been subjected to repeated administrations of electro-convulsive shock and insulin coma therapy. These therapies should have produced damage to the central nervous system in addition to the damage resulting from normal aging and should have further reduced the schizophrenic's efficiency (Maher, 1966). On no test was there a greater loss with age in the schizophrenics than in the normal subjects.

Aging seemed to have the same relative effects on the cognitive capacities of the schizophrenics as on those of the normal subjects. On most of the measures there was no interaction between pathology and aging; the schizophrenic deficits were present to the same degree in both the younger and older subjects. This finding would seem to negate Binder's (1956) suggestion that the deficit in schizophrenia masks the effects of aging. The only task that might be said to reveal such a masking effect was the maze task where an interaction between pathology and age occurred. This significant interaction reflected a smaller difference between the scores of the older subjects than between the scores of the two younger groups. An explanation of this single finding in terms of a more severe aging effect in normal subjects than in schizophrenics seems illogical. It is more parsimonious to assume that there could be an abatement of some aspects of the schizophrenic disorder. Evidence for abatement of the disorder would have important implications for theories of schizophrenia which consider it to be a deteriorative process. It would also have implications for theories which postulate a biochemical factor in the etiology of schizophrenia; the presence and influence of such possible factors would have to be shown to change with age.

Consider now the performance of subjects on the individual tasks administered.

McGill Picture Anomaly Series

Although schizophrenic subjects took longer to complete this task and identified fewer anomalies correctly than normal subjects, both groups showed the same amount of decrement with age. The poorer performance of the schizophrenic groups on the series provides confirmation for the work of Penrose (1945) and Schwartzman and Douglas (1962) who reported that such patients were unable to recognize the absurd and to respond appropriately to social incongruities. The poorer performance of the older normal subjects was consistent with data reported by Hebb and Morton (1943) in the original standardization of the test. It is important to point out that the difficulty which the schizophrenics and elderly normal subjects had in identifying the anomalies appeared not to be the result of a lack of motivation or attention. The task was individually administered, and it was observed that both spent more time examining each picture than did younger normal subjects. The fact that the schizophrenics showed an age effect equal to that observed for the normal subjects, and the fact that the schizophrenic decrement was present to the same degree in both the younger and older subjects, lead one to assume that the performance of the older schizophrenics reflected the normal aging effect plus whatever deficit is unique to schizophrenia. The task requires that the subject integrate the details of the picture, draw a conclusion about its theme, and then recognize the incongruity. It is tempting to speculate that the schizophrenic deficit is related to known associative abnormalities, while the aging effect results from an inability to attend to detail.

Verbal Fluency Test

On both the restricted (animal-naming) and unrestricted (word-naming) parts of the verbal fluency test, the schizophrenic subjects said less in one minute than the normal subjects. Age reduced the fluency of the schizophrenic and normal subjects equally. The poorer performance of the schizophrenics when naming members of a particular concept was consistent with the Eysencks' finding (Eysenck, J.J., 1952; Eysenck, S.B.G., 1955), but their poorer performance on the word-naming task disagreed with Eysenck's finding (Eysenck, H.J., 1952). This difference in results may be caused by the fact that Eysenck used a longer time period for the word-naming task. It is possible that the schizophrenics' performance deteriorates in reaction to time pressure. The reduced fluency of the older normal group on the unrestricted task was in agreement with the results found by Birren, Riegel, and Robbin (1962). More responses were given by all groups on the unrestricted task; there was no interaction between category and either pathology or age. Thus all groups reacted to constraint in a similar fashion, and the difference between the restricted and unrestricted tasks simply represented the difference in the available number of appropriate responses. The deficit in verbal fluency in the aged has been attributed to their diminished ability to inhibit interfering inappropriate responses (Birren, 1955; Birren, Riegel, & Robbin, 1962). Such an explanation could hardly account for deficits on a completely unrestricted word-naming task, however, since on such a task all responses are appropriate. Moreover, it is difficult to attribute the differences to differences in vocabulary size, since subjects were matched with respect to WAIS vocabulary score. It seems more likely that the poorer performance of the elderly normal subject on this task can be accounted for by the well-documented general slowing of their response output. As for the schizophrenics, their poorer performance might be attributed to the exaggerated response to time pressure mentioned earlier.

Tapping Test

It was found that both groups of schizophrenics tapped more slowly in the 10-sec. periods than did the normal control groups. This finding provides further confirmation of the motor retardation in schizophrenia found by Shakow and Huston (1936) and King (1954) on similar tapping tests. Both schizophrenic and older normal subjects also tapped more slowly than their younger counterparts. The finding of a motor slowness in older normal people was consistent with the data reported by Csank and Lehmann (1958), although their procedure was different. King (1954) also reported that tapping performance deteriorated with age in normal subjects. In addition,he stated than in schizophrenia there was an improvement in tapping performance with age. The data in the present study, however, did not support his contention. While the age effect obtained was weak, and an examination of the tapping data suggested that it was caused mainly by the normal subjects, there was no interaction. The only conclusion that can be drawn is that performance of the older schizophrenic reflects both a normal age effect and a schizophrenic deficit. The slowness in tapping with age is probably the result of a combination of changes in the muscles and joints, and changes in the conduction rate in the nervous system (Birren, 1964). Although the additional deficit in schizophrenia may be accounted for by the increased muscular tension known to occur in schizophrenia and known to become exaggerated in chronic schizophrenics (Lang & Buss, 1965), this deficit may be at least partially affected by the medication and life-style of hospitalized schizophrenics. In any event, it is clear that the performance decrement in both the schizophrenics and the older normal subjects was not the result of a lack of motivation, because all groups showed the same amount of consistent improvement over the three blocks of trials.

Digit-Span and Dichotic Listening Tasks

The only effect found on the digit-span tests was one of presentation rate. It is clear from the data that under precisely standardized conditions using a recorded presentation procedure, as was the case in the present study, there is no difference between either schizophrenic and normal subjects or older and younger ones on forward digit-span performance under the standard presentation rate of 1 digit/1 sec. The fact that all subjects showdd poorer recall of digits at the slow presentation rate is consistent with the findings of Conrad (1957) and Fraser (1958). The failure to detect at the slower presentation rates a greater deficit in the schizophrenics and the elderly normal subjects than in the younger normal subjects suggests that at all three presentation rates all subjects were equal in their ability to perceive the digits and in their immediate ability to recall them.

There was incomplete counterbalancing of the order in which the amounts of material and presentation rates were administered on the dichotic listening task. Nevertheless, the standard relations between both accuracy and strategy of report, and amount of material and presentation rate (e.g. Broadbent, 1954, 1957; Bryden, 1962, 1964) were obtained. In general, temporal order reports predominated at the slowest presentation rate and ear order reports at the fastest presentation rate. In addition, when the amount of material in a series was increased, there was a reduction in the use of both ear and temporal orders of report, and a concomitant increase in less systematic methods of responding. Accuracy of report for all subjects was better with shorter series than with longer ones. Also, as the presentation rate was slowed, accuracy improved. The interactions between amount of material and presentation rate detected in the analyses of ear order frequency, temporal order frequency, and accuracy of report have not been seen before with normal subjects. The present study, however, used a different range of amount of material (2- to 4- pair as opposed to 3- to 5- pair as in Bryden, 1962). These interactions essentially reflect the fact that differences between series of different lengths were maximized at the presentation rate which was most effective in eliciting a particular order of report; alternatively, the difference between series of different lengths practically disappeared at the rate on which the use of the report order was minimal. With respect to accuracy of report, the interaction occurred, as might be expected, because the 2- pair series was relatively easy and, consequently, was not very sensitive to the presentation rate effect.

There was no evidence that older subjects differed in their organization of dichotically presented digits; the older subjects of both groups used frequencies of both ear and temporal order of report similar to those of their younger counterparts. The only way in which the older subjects showed their age was in their reduced accuracy of digit report. Despite the fact that there was no decrement in performance with series of single digits at the same presentation rates as those used for the dichotic presentation, there was an impairment in recall when two digits were presented simultaneously. This finding clearly provides additional support for the evidence of Inglis and his co-workers (e.g. Inglis & Caird, 1963; Mackay & Inglis, 1963) that there is a decline in the efficiency of short-term memory in elderly people. The fact that the impairment of recall in elderly normal subjects occurred at the two faster presentation rates but not at the slow rate makes it clear that the decrement in accuracy is not a result of an inability to attend to information coming into both ears at once.

Qualitative differences were found with schizophrenic subjects in the organization of dichotic material. Although the schizophrenic's responses can be classified in the same way as the report of normal subjects, and although there was no increase in unsystematic orders of report, both younger and older schizophrenics made more use of ear order and less use of temporal order report than the normal control groups. In addition, although the schizophrenic's use of ear order report was affected by the length of the series in the same way as that of the normal subjects, their use of temporal order report was not altered by changes in the amount of material. The schizophrenics were, in general, less accurate than the normal subjects. Bryden (1962) has shown that in normal subjects accuracy is reduced when ear order is used at slow rates. Thus, when the schizophrenic uses ear order report at the slow rate, by normal standards he is actually making the task harder for himself by increasing the burden on the short-term memory storage. In his choice of this mode of response he is acting as if he or his perceptual system were under pressure at the slower presentation rates. The loss of accuracy demonstrated by the schizophrenics for the 2- and 3- pair series at the slow presentation rate may be attributed to their insufficient use of temporal order report. With 4- pair material, however, at the slow presentation rate both schizophrenics and normal subjects used the same amount of temporal order report, and yet the recall of the schizophrenics remained poorer. Moreover, for the 4- pair series at the fast rate, although the schizophrenics used as much if not more ear order report as the normal subjects, they again showed a deficit. This implies that there is still some memory problem besetting the schizophrenic which is demonstrable only when his memory is taxed. This accuracy deficit may be a reflection of either a subtle impairment of the short-term memory storage or the reduced effectiveness of the retrieval process. Such deficit is probably not the result of an inability to register the information arriving at both ears because the schizophrenics showed no deficit with 2- and 3- pair series at the faster presentation rate.

One theory of schizophrenic dysfunction developed by Chapman & McGhie (1962, 1963, 1964) has been applied by Yates (1966) directly to the dichotic listening situation. Yates suggested that if the material was presented at a slower rate, schizophrenics would have less difficulty processing the information; consequently, their storage capacity would not be overloaded, and recall would be improved. The finding in the present study does not confirm Yates' hypothesis. It is true that when the presentation rate was slowed, there was some improvement in the accuracy of the schizophrenic group; yet, relative to the normal group, the schizophrenics' decrement was actually greater at the slow presentation rate.

Stepping-Stone Maze

The results of the stepping-stone maze task were especially interesting because there were measures which showed only the effect of age and others which were sensitive only to schizophrenia. In addition, on this test there were interactions of pathology and age. The fact that this task was the most complex and challenging to the subject is reflected in the excessive loss of subjects due to their inability to complete the task. There is no apparent distortion of results because of the selection factor since the subject loss of schizophrenic subjects was almost equally distributed between the two schizophrenic groups.

Both the elderly schizophrenic and normal subjects had poorer recall of the maze 24 hours after they had learned the path to the same criterion as the younger subjects. This deficit after 24 hours is consistent with the findings of Hulicka & Rust (1964) and Wimer (1960) even though they used other tasks. It is quite clear, then, that older subjects have a memory problem which involves both long-term and short-term storage. It is the short-term memory deficit which probably accounts for the difficulty which the older subjects had in learning the maze to criterion on both test sessions. Older subjects also traced the path of the maze more slowly after they had learned it. This measure was another reflection of their generalized slowing-down in all areas of functioning (Birren, 1964).

Schizophrenics were not slower than normal subjects at tapping the path of the maze on the criterion trials. This clearly suggests that schizophrenics progress at the same tempo when the task is self-paced. This task also provides further confirmation that the long-term memory of the schizophrenic is not impaired because there was no deficit in 24-hour recall of the path.

The interaction that occurred on three of the maze measures--trials-to-criterion, instructional errors, and repeated errors-- reflected the fact that older schizophrenics did not function more poorly than younger ones so that only normal subjects showed the age effect. The net result was a significant schizophrenic effect at the younger age and little or no effect at the older age. This paradoxical result is difficult to explain, but it cannot be accounted for by a ceiling effect on the task. Since on all the other tasks schizophrenic and normal subjects showed the same amount of change with age, it does not seem likely that only on this task they would fail to show an age effect. Consequently, as already hypothesized, one possible interpretation is that they no longer showed the schizophrenic effect. An examination of the similar performance of both groups of schizophrenics and the elderly normal subjects suggests that part of the difficulty in initial acquisition of the maze path was a result of the inability of the subjects in all three groups to follow the multiple instructions given to them. Although all three groups had difficulty following instructions, it should be pointed out that while older normal subjects made as many retracing and no-return errors as the schizophrenics did, they rarely made diagonal errors. It appears as if not making diagonal errors is a sign of normality. All three groups showed their spatial confusion by the fact that they made more repeated errors on the maze, and these repeated errors increased their learning difficulty in the first session. It is of interest to note that schizophrenics and elderly normal subjects seemed to make fewer instructional errors but more repeated errors than the frontal lobe patients in Milner's (1965) study. Difficulty in following the instructions and repetition of errors cannot completely account for the learning deficit. On the second session all three groups took longer than the younger normal subjects to relearn the path, even though the number of instructional and repeated errors on that day was negligible. As has already been suggested, the learning difficulty in the older subjects, both schizophrenics and normal, was probably a reflection of the memory deficit in the elderly. It is difficult to speculate from the evidence available exactly what factor slowed or interfered with the learning of younger schizophrenics without affecting the performance of older schizophrenics.

General Considerations

The detailed examination of the individual test results and the consideration of the possible factors underlying performance decrements of schizophrenics clearly suggest that schizophrenia cannot be characterized by a unitary deficit. Theories which postulate a single and separately identifiable deficit in schizophrenia would appear to be unable to account for the multiple task deficits found in the present study. Furthermore, the present findings provide little support for theories which postulate a single underlying process to explain the deficits found in schizophrenia. These conclusions are consistent with those of Price (1968) who found that there were many sources of variance contributing to the schizophrenic's difficulty in the area of concept formation. Perhaps the most important conclusion to be drawn from this study is that, as in aging, where one would not be tempted to postulate a single process dysfunction to explain multiple psychological changes, neither should one expect to find a single process "gone wrong" in such a diverse and multi-faceted mental pathology as schizophrenia.

The present study does demonstrate the usefulness of highlighting the deficits of schizophrenia against those which occur as a function of aging. Some schizophrenic deficits could be differentiated both in degree and in kind from normal age changes. Further research is required to establish the actual mechanisms which underlie schizophrenic pathology. Experimental manipulation of task variables within a similar paradigm may provide some useful answers.

There was no indication in the present study that progressive deterioration was a necessary end product of schizophrenia. Even in a fairly homogeneous group of nonparanoid schizophrenics for whom deterioration is often considered to be the end result, there was no evidence of progressive loss. It appears that what has often been considered deterioration in schizophrenics may be nothing other than the normal effect of aging.

Summary

Schizophrenic and normal changes with age in cognitive and psychomotor capacities were investigated by comparing the performance of younger and older chronic schizophrenics with younger and older normal subjects. There were 21 subjects in each group. The mean ages of the younger and older groups were 43 and 66 years respectively. The following tasks were administered: an oral fluency test, the McGill Picture Anomaly Series (M), a stepping-stone maze learning and retention task, a digit-span test, a dichotic listening task, and a tapping test. Both schizophrenia and age significantly reduced performance efficiency. Some schizophrenic deficits could be differentiated both in degree and in kind from normal age changes. The finding that the amount of change with age for the schizophrenic subjects was either the same as or less than that for the normal subjects demonstrated clearly that progressive deterioration even in nonparanoid schizophrenics is not a necessary concomitant of schizophrenia.

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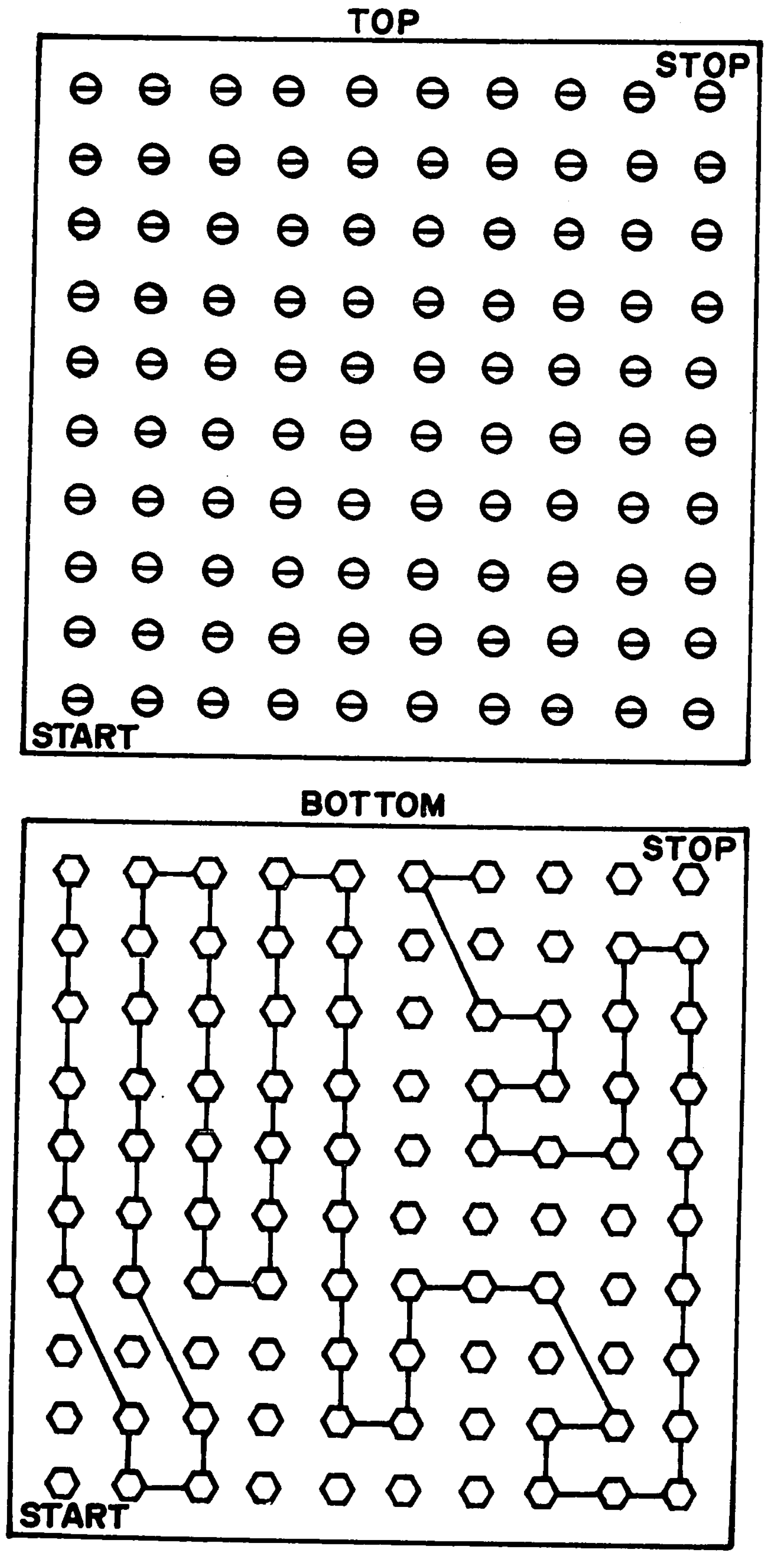
Appendix I

The Stepping-Stone Maze Apparatus



Schematic representation of the upper surface (top diagram) and the wiring (bottom diagram) on the stepping-stone maze.

Appendix II

Stimulus Materials for the Dichotic Listening Task

Practice Series in the Dichotic Listening Task

Channel 1	Channel 2
4	7
5	8
6	9
2	6
10	7
5	1
1	4
3	8
7	2
8	5
4	9
6	10
9	3

Two-Pair Series in the Dichotic Listening Task

Presentation Rate	Channel 1		Channel 2	
sec.	7	9	5	2
	3	4	2	9
	9	10	7	1
	2	7	1	6
	4	2	3	10
	10	8	9	5
	1	3	10	7
	6	5	4	8
	8	1	6	3
	5	6	8	4
1 sec.	6	2	10	3
	3	10	9	1
	5	6	7	2
	1	8	4	6
	9	1	6	8
	7	4	2	5
	2	3	8	4
	10	7	5	9
	8	9	1	10
	4	5	3	7
2 sec.	3	7	6	5
	2	6	5	10
	1	5	7	3
	5	1	10	9
	10	2	8	1
	8	3	4	7
	9	8	2	4
	7	9	3	6
	6	4	9	2
	4	10	1	8

Note.-For each channel, the letters of each pair are listed in temporal sequence from left to right.

Three-Pair Series in the Dichotic Listening Task

Presentation Rate	Channel 1			Channel 2		
sec.	4	2	7	8	9	3
	3	7	9	6	2	8
	10	5	6	9	7	1
	1	6	5	2	10	4
	7	9	10	3	8	2
	9	10	8	7	3	5
	5	8	1	10	4	9
	8	4	2	5	1	6
	2	1	3	4	6	10
	6	3	4	1	5	7
1 sec.	9	3	10	7	2	6
	5	9	1	10	6	8
	10	6	2	8	1	3
	6	2	3	5	7	10
	3	1	8	9	10	4
	1	7	4	3	9	5
	8	10	7	4	3	9
	4	8	9	2	5	1
	7	5	6	1	4	2
	2	4	5	6	8	7
2 sec.	6	1	5	2	4	8
	3	9	8	7	2	4
	7	5	1	4	3	6
	4	10	2	5	6	1
	9	4	10	1	8	5
	5	3	7	8	10	9
	10	6	4	3	1	2
	8	2	6	9	7	3
	2	8	3	10	9	7
	1	7	9	6	5	10

Note.-For each channel, the letters of each pair are listed in temporal sequence from left to right.

Four-Pair Series in the Dichotic Listening Task

Presentation Rate	Channel 1				Channel 2			
sec.	7	9	7	3	5	2	10	8
	3	4	1	4	2	9	6	5
	9	10	6	8	7	1	3	1
	2	7	8	9	1	6	5	3
	4	2	5	1	3	10	7	6
	10	8	3	2	9	5	4	7
	1	3	4	6	10	7	9	2
	6	5	2	10	4	8	1	9
	8	1	10	5	6	3	2	4
	5	6	9	7	8	4	8	10
1 sec.	6	2	8	1	10	3	9	4
	3	10	7	5	9	1	8	6
	5	6	1	6	7	2	4	9
	1	8	9	10	4	6	2	7
	9	1	10	4	6	8	7	3
	7	4	3	9	2	5	10	8
	2	3	2	7	8	4	6	5
	10	7	4	3	5	9	5	1
	8	9	5	2	1	10	3	10
	4	5	6	8	3	7	1	2
2 sec.	3	7	8	10	6	5	1	9
	2	6	9	7	5	10	3	8
	1	5	2	4	7	3	8	3
	5	1	6	3	10	9	2	4
	10	2	5	6	8	1	4	7
	8	3	10	9	4	7	6	1
	9	8	7	8	2	4	5	10
	7	9	1	5	3	6	10	2
	6	4	3	1	9	2	9	5
	4	10	4	2	1	8	7	6

Note.-For each channel, the letters of each pair are listed in temporal sequence from left to right.

Appendix III

Stimulus Materials for the Digit-Span Power Test

Digit Series in the Digit-Span Power Test for the Half-Second Trial Block

6	8							
4	3							
7	1	5						
9	6	2						
8	3	7	5					
3	9	4	7					
5	2	8	4	10				
2	7	10	6	9				
1	9	8	10	5	6			
10	7	5	9	3	1			
6	3	8	1	7	2	4		
9	4	6	5	3	10	8		
4	9	1	8	3	7	6	2	
7	4	8	5	2	10	1	6	
2	8	7	1	10	3	4	6	9
1	6	5	3	4	8	7	2	10

Digit Series in the Digit-Span Power Test for the

One Second Trial Block

2	9							
8	1							
10	3	7						
4	1	6						
5	7	1	9					
1	10	8	2					
9	3	2	7	8				
6	9	4	8	3				
7	4	10	3	5	2			
3	8	5	6	4	10			
2	10	6	1	8	7	4		
9	6	10	4	1	2	7		
5	4	6	3	9	2	7	5	
3	8	6	9	4	5	10	1	
4	5	10	3	8	6	1	2	9
7	1	5	4	10	6	9	3	8

Digit Series in the Digit-Span Power Test for the

Two Second Trial Block

5	10							
9	7							
1	8	3						
2	5	8						
7	2	10	3					
4	8	6	1					
3	1	7	8	2				
10	8	1	9	4				
8	5	2	6	7	9			
6	10	4	7	1	5			
7	1	4	10	3	8	9		
3	5	10	2	4	9	6		
1	6	3	2	8	10	5	4	
9	5	7	10	2	4	3	6	
10	1	4	7	3	8	9	6	2
5	7	1	6	9	3	10	4	8

Appendix IV

Tables of Analyses of Variance

Table A

Analysis of Variance of Verbal Fluency Log Scores as a Function of Pathology, Age, and Type of Test

Source of Variation	df	MS	F	
<u>Between subjects</u>	<u>83</u>			
Pathology (P)	1	.27848	8.66	$p < .005$
Age (A)	1	.15482	4.82	$p < .05$
P x A	1	.05358	1.67	
Subjects within groups	80	.03214		
<u>Within subjects</u>	<u>84</u>			
Type of Test (T)	1	.19475	19.11	$p < .001$
P x T	1	.00483	< 1	
A x T	1	.02987	2.93	
P x A x T	1	.00028	< 1	
T x subject within groups	80	.01019		

Table B

Analysis of Variance of Number of Anomalies Recognized on the McGill Picture Anomaly Series as a Function of Pathology and Age

Source of Variation	df	MS	F	
Total	83			
Pathology (P)	1	344.05	17.40	$p < .001$
Age (A)	1	267.86	13.55	$p < .001$
P x A	1	6.85	< 1	
Within cell	80	19.77		

Table C

Analysis of Variance of Time Scores on the McGill Picture Anomaly Series as a Function of Pathology and Age

Source of Variation	df	MS	F	
Total	83			
Pathology (P)	1	219.35	15.99	p < .001
Age (A)	1	196.51	14.32	1 < .001
P x A	1	.02	<1	
Within cell	80	13.72		

Table D

Analysis of Variance of Stepping-Stone Maze Trials to Criterion (log scores) as a Function of Pathology, Age, and Test Session

Source of Variation	df	MS	F	
Between subjects	83			
Pathology (P)	1	.9783	12.46	$p < .001$
Age (A)	1	2.3810	30.33	$p < .001$
P x A	1	.6713	8.55	$p < .005$
Subjects within groups	80	.0785		
Within subjects	84			
Test Session (T)	1	11.0265	373.78	$p < .001$
P x T	1	.0360	1.22	
A x T	1	.0823	2.79	
P x A x T	1	.0189	< 1	
T x subject within groups	80	.0295		

Table E

Analysis of Variance of Instructional Errors [$\log_{(n+1)}$scores] on Stepping-Stone Maze Acquisition as a Function of Pathology, Age, and Type of Error

Source of Variation	df	MS	F	
Between subjects	83			
Pathology (P)	1	6.5701	24.82	$p < .001$
Age (A)	1	1.7919	6.77	$p < .025$
P x A	1	2.2121	8.36	$p < .005$
Subjects within groups	80	.2647		
Within subjects	168			
Type of Error (T)	2	5.8576	81.47	$p < .001$
P x T	2	.0205	< 1	
A x T	2	.2724	3.79	$p < .025$
P x A x T	2	.4696	6.53	$p < .005$
T x subject within groups	160	.0719		

Table F

Analysis of Variance of Repeated Errors [$\log_{(n+1)}$ scores] on Stepping-Stone Maze Acquisition as a Function of Pathology and Age

Source of Variation	df	MS	F	
Pathology (P)	1	4.8192	30.81	$p < .001$
Age (A)	1	.3549	2.27	
P x A	1	1.1247	7.19	$p < .01$
Within cell	80	.1564		

Table G

Analysis of Variance of Mean Criterion Trial Speed on the Stepping-Stone Maze as a Function of Pathology, Age, and Test Session

Source of Variation	df	MS	F	
<u>Between subjects</u>	<u>83</u>			
Pathology (P)	1	196.08	1.36	
Age (A)	1	1351.50	9.34	$p < .005$
P x A	1	11.27	< 1	
Subjects within groups	80	144.67		
<u>Within subjects</u>	<u>84</u>			
Test Session (T)	1	23.25	1.17	
P x T	1	10.26	< 1	
A x T	1	.12	< 1	
P x A x T	1	6.67	< 1	
T x subject within groups	80	19.84		

Table H

Analysis of Variance of Stepping-Stone Maze Errors on the First Relearning Trial as a Function of Pathology and Age

Source of Variation	df	MS	F	
Pathology (P)	1	27.428	3.72	
Age (A)	1	42.857	5.80	$p < .025$
P x A	1	9.333	1.26	
Within cell	80	7.383		

Table I

Analysis of Variance of Mean Tapping Scores as a Function of Pathology, Age, and Trial Block

Source of Variation	df	MS	F	
Between subjects	83			
Pathology (P)	1	3,096.82	27.96	$p < .001$
Age (A)	1	570.61	5.15	$p < .05$
P x A	1	108.03	< 1	
Subjects within groups	80	110.76		
Within subjects	168			
Trial-Block (T)	2	34.58	10.05	$p < .001$
P x T	2	.23	< 1	
A x T	2	1.21	< 1	
P x A x T	2	4.19	1.22	
T x subject within groups	160	3.44		

Table J

Analysis of Variance of Ear Order Reports as a Function of Pathology, Age, Amount of Material, and Presentation Rate

Source of Variation	df	MS	F	
Between subjects	83			
Pathology (P)	1	635.25	15.16	$p < .001$
Age (A)	1	58.89	1.40	
P x A	1	2.92	<1	
Subjects within groups		41.88		
Within subjects	672			
Amount of Material (M)	2	190.06	33.29	$p < .001$
P x M	2	31.22	5.47	$p < .005$
A x M	2	1.13	<1	
P x A x M	2	.95	<1	
M x Subject within groups	160	5.70		
Presentation Rate (R)	2	486.19	94.13	$p < .001$
P x R	2	2.11	<1	
A x R	2	.40	<1	
P x A x R	2	4.08	<1	
R x Subject within groups	160	5.16		
M x R	4	17.40	3.57	$p < .01$
P x M x R	4	3.25	<1	
A x M x R	4	4.87	1.00	
P x A x M x R	4	3.62	<1	
MR x Subject within groups	320	4.86		

Table K

Analysis of Variance of Temporal Order Reports as a Function of Pathology, Age, Amount of Material, and Presentation Rate

Source of Variation	df	MS	F	
Between subjects	83			
Pathology (P)	1	448.04	10.68	$p < .005$
Age (A)	1	66.37	1.58	
P x A	1	10.72	< 1	
Subjects within groups	80	41.94		
Within subjects	672			
Amount of Material (M)	2	153.78	19.74	$p < .001$
P x M	2	123.02	15.79	$p < .001$
A x M	2	18.71	2.40	
P x A x M	2	2.34	< 1	
M x Subject within groups	160	7.79		
Presentation Rate (R)	2	459.37	79.20	$p < .001$
P x R	2	8.20	1.41	
A x R	2	2.82	< 1	
P x A x R	2	2.68	< 1	
R x Subject within groups	160	5.80		
M x R	4	37.91	12.68	$p < .001$
P x M x R	4	6.31	2.11	
A x M x R	4	8.21	2.75	$p < .05$
P x A x M x R	4	1.62	< 1	
MR x Subject within groups	320	2.99		

Table L

Analysis of Variance of Accuracy Scores (in per cent) as a Function of Pathology, Age, Amount of Material, and Presentation Rate

Source of Variation	df	MS	F	
<u>Between subjects</u>	<u>83</u>			
Pathology (P)	1	4377.77	10.49	$p < .005$
Age (A)	1	2201.53	5.32	$p < .025$
P x A	1	10.93	< 1	
Subject within groups	80	413.41		
<u>Within subjects</u>	<u>672</u>			
Amount of Material (M)	2	33586.58	704.86	$p < .001$
P x M	2	225.89	4.74	$p < .01$
A x M	2	5.42	< 1	
P x A x M	2	42.79	< 1	
M x Subject within groups	160	47.65		
Presentation Rate (R)	2	979.24	32.23	$p < .001$
P x R	2	189.97	6.25	$p < .005$
A x R	2	45.76	1.50	
P x A x R	2	104.01	3.42	$p < .05$
R x Subject within groups	160	30.38		
M x R	4	86.01	4.46	$p < .005$
P x M x R	4	61.58	3.19	$p < .025$
A x M x R	4	16.99	< 1	
P x A x M x R	4	19.06	< 1	
MR x Subject within groups	320	19.26		

Table M

Analysis of Variance of the Digit-Span Scores as a Function of Pathology, Age, and Presentation Rate

Source of Variation	df	MS	F	
<u>Between subjects</u>	<u>83</u>			
Pathology (P)	1	1.7500	<1	
Age (A)	1	.4802	<1	
P x A	1	.0357	<1	
Subjects within groups	80	3.7175		
<u>Within subjects</u>	<u>168</u>			
Presentation Rate (R)	2	2.0159	3.17	p< .05
P x R	2	.9048	1.42	
A x R	2	.2063	<1	
P x A x R	2	.3334	<1	
S x subject within groups	160	.6359		

Appendix V

Tables of Means and Standard Deviations

Table A

Verbal Fluency Test: Group Means and Standard Deviations for Number of Responses Given

Category		Schizophrenics		Controls	
		Younger	Older	Younger	Older
Animal Naming	Mean	13.6	13.7	17.8	14.6
	S.D.	3.5	3.5	5.7	3.0
Word Naming	Mean	17.2	15.3	23.1	16.4
	S.D.	6.2	7.1	9.1	4.1

Table B

McGill Picture Anomaly Series: Group Means and Standard Deviations for Number Correct and Time Required

Measure		Schizophrenics		Controls	
		Younger	Older	Younger	Older
Number Correct	Mean	21.6	17.5	25.1	22.1
	S.D.	4.3	5.3	4.1	3.6
Time in Minutes	Mean	11.1	14.1	7.8	10.9
	S.D.	4.2	4.2	3.3	2.5

Table C

Stepping-Stone Maze: Group Means and Standard Deviations for Number of Trials to Criterion

Session		Schizophrenics		Controls	
		Younger	Older	Younger	Older
First	Mean	44.1	49.2	20.2	45.8
	S.D.	17.6	18.7	7.1	18.6
Second	Mean	11.4	17.4	6.9	18.0
	S.D.	5.3	8.3	4.2	12.0

Table D

Stepping-Stone Maze Acquisition: Group Means and Standard Deviations for Instructional and Repeated Errors

Type of Error		Schizophrenics		Controls	
		Younger	Older	Younger	Older
Retracing	Mean	12.8	11.7	2.6	9.4
	S.D.	10.9	7.0	2.4	6.4
Diagonal	Mean	4.3	3.6	.5	1.2
	S.D.	6.4	4.6	.7	2.5
No-Return	Mean	10.8	7.6	1.1	9.2
	S.D.	11.6	7.0	1.3	12.1
Repeated	Mean	15.4	9.3	1.5	8.9
	S.D.	14.5	6.2	1.5	12.8

Table E

Stepping-Stone Maze: Group Means and Standard Deviations for Mean Criterion Trial Speed in Seconds

Session		Schizophrenics		Controls	
		Younger	Older	Younger	Older
First	Mean	25.2	30.7	23.5	29.2
	S.D.	7.8	7.3	10.1	6.2
Second	Mean	25.3	30.1	21.8	28.4
	S.D.	11.1	8.3	11.7	6.4

Table F

Stepping-Stone Maze: Group Means and Standard Deviations for Total Number of Errors on the First Relearning Trial

	Schizophrenics		Controls	
	Younger	Older	Younger	Older
Mean	5.3	6.1	3.5	5.6
S.D.	2.7	2.5	2.5	2.9

Table G

Tapping Test: Group Means and Standard Deviations for each Block of Trials

Trial Block		Schizophrenics		Controls	
		Younger	Older	Younger	Older
First	Mean	40.4	38.3	48.2	44.5
	S.D.	5.9	5.5	5.7	5.7
Second	Mean	41.2	39.5	49.7	44.8
	S.D.	6.6	6.3	5.5	6.7
Third	Mean	41.1	39.8	49.7	45.4
	S.D.	6.7	5.5	5.9	7.2

Table H

Dichotic Listening Task: Group Means and Standard Deviations for Frequency of Ear Order Report

Amount of Material	Presentation Rate		Schizophrenics Younger	Schizophrenics Older	Controls Younger	Controls Older
2 pairs	1 pr./½ sec.	Mean	6.7	7.4	5.4	4.8
		S.D.	2.7	2.5	3.4	3.2
	1 pr./1 sec.	Mean	5.2	5.5	2.2	3.8
		S.D.	3.9	3.5	3.2	3.6
	1 pr./2 sec.	Mean	3.7	4.1	.5	1.2
		S.D.	3.9	3.6	1.3	2.4
3 pairs	1 pr./½ sec.	Mean	5.1	6.3	3.8	4.1
		S.D.	2.4	2.7	3.4	3.0
	1 pr./1 sec.	Mean	4.7	5.1	2.7	2.7
		S.D.	3.2	3.1	3.3	2.7
	1 pr./2 sec.	Mean	2.7	3.7	.6	1.8
		S.D.	2.9	3.1	1.3	2.6
4 pairs	1 pr./½ sec.	Mean	3.8	4.6	2.6	3.4
		S.D.	2.3	2.1	2.5	2.7
	1 pr./1 sec.	Mean	2.7	3.0	1.6	1.9
		S.D.	3.5	2.2	1.7	2.3
	1 pr./2 sec.	Mean	1.7	2.4	1.3	1.1
		S.D.	2.3	2.0	1.9	1.3

Table I

Dichotic Listening Task: Group Means and Standard Deviations for Frequency of Temporal Order Report

Amount of Material	Presentation Rate		Schizophrenics Younger	Schizophrenics Older	Controls Younger	Controls Older
2 pairs	1 pr./½ sec.	Mean	2.6	1.9	3.9	4.1
		S.D.	2.9	2.3	3.4	3.3
	1 pr./1 sec.	Mean	3.8	3.0	7.1	5.4
		S.D.	4.1	3.6	3.7	3.9
	1 pr./2 sec.	Mean	5.5	4.9	8.9	8.3
		S.D.	4.0	4.1	2.2	2.8
3 pairs	1 pr./½ sec.	Mean	2.5	1.1	3.5	3.4
		S.D.	2.4	1.6	3.1	2.8
	1 pr./1 sec.	Mean	3.3	2.6	4.9	4.8
		S.D.	3.2	3.0	3.7	3.1
	1 pr./2 sec.	Mean	5.5	3.5	7.8	6.0
		S.D.	3.4	3.2	2.3	3.1
4 pairs	1 pr./½ sec.	Mean	3.0	2.4	2.7	2.8
		S.D.	2.3	2.0	1.9	2.0
	1 pr./1 sec.	Mean	3.5	3.2	3.3	3.9
		S.D.	2.4	2.0	2.1	2.2
	1 pr./2 sec.	Mean	4.2	4.1	3.6	4.0
		S.D.	2.5	2.8	2.2	2.1

Table J

Dichotic Listening Task: Group Means and Standard Deviations for Accuracy Scores (in per cent)

Amount of Material	Presentation Rate		Schizophrenics		Controls	
			Younger	Older	Younger	Older
2 pairs	1 pr./½ sec.	Mean	93.4	90.8	96.6	92.0
		S.D.	7.6	7.8	3.8	5.7
	1 pr./1 sec.	Mean	93.4	88.6	95.6	92.2
		S.D.	7.7	9.2	4.9	6.5
	1 pr./2 sec.	Mean	94.2	92.7	98.3	96.7
		S.D.	7.1	5.2	3.0	4.4
3 pairs	1 pr./½ sec.	Mean	80.5	81.2	85.3	78.7
		S.D.	8.4	9.9	9.3	8.6
	1 pr./1 sec.	Mean	84.2	80.4	88.7	83.8
		S.D.	9.3	8.4	7.7	8.8
	1 pr./2 sec.	Mean	83.8	79.6	91.5	88.8
		S.D.	10.7	10.2	8.2	8.3
4 pairs	1 pr./½ sec.	Mean	66.2	64.4	72.9	70.1
		S.D.	8.6	7.6	9.3	9.4
	1 pr./1 sec.	Mean	69.8	64.4	76.0	71.6
		S.D.	8.6	9.1	8.1	8.8
	1 pr./2 sec.	Mean	72.1	67.0	78.1	75.9
		S.D.	10.8	9.5	8.7	9.9

Table K

Digit-Span Power Test: Group Means and Standard Deviations for Maximum Number of Digits Recalled

Presentation Rate		Schizophrenics		Controls	
		Younger	Older	Younger	Older
½ sec.	Mean	6.3	6.0	6.1	6.1
	S.D.	1.3	1.3	.9	1.3
1 sec.	Mean	5.8	5.8	6.1	6.1
	S.D.	1.4	1.3	.9	1.0
2 sec.	Mean	5.7	5.7	6.1	5.8
	S.D.	1.5	1.5	1.2	1.3