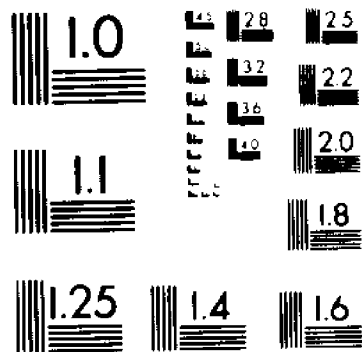
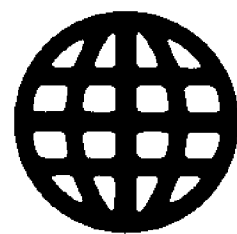


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PERCEPTUAL ORGANIZATION IN SCHIZOPHRENIA

by

BARBARA KATCHER ORLOWSKI

**A dissertation submitted to the Graduate Faculty
in Psychology in partial fulfillment of the
requirements for the degree of Doctor of
Philosophy, The City University of New York.**

1986

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This manuscript has been read and accepted for the Graduate Faculty in Psychology in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy.

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Abstract

PERCEPTUAL ORGANIZATION IN SCHIZOPHRENIA

by

Barbara Katcher Orlowski

Adviser: Professor Mitchell L. Kietzman.

Previous research has indicated that a perceptual organizational deficit, as measured by response accuracy, appears to exist for schizophrenic persons in an early stage of visual perceptual processing. The present experiment was designed to determine whether the differences in perceptual organization among schizophrenic and two groups of normal subjects (young and elderly) were also reflected in response latency (reaction time).

Subjects were presented with three to six horizontal and/or vertical bars of light placed at the points of an imaginary hexagon. The bars of light in each stimulus display were presented in one of three crosscutting conditions of perceptual organization which increased in complexity: a Homogeneous condition (either all horizontal or all vertical bars), a Heterogeneous/Adjacent condition (horizontal bars

adjacent to vertical bars), and a Heterogeneous/Nonadjacent condition (alternating horizontal and vertical bars). The subjects were told only to report the number of bars presented. Subjects were tested twice: near hospital admission and close to discharge. With a voice microphone, reaction time and response accuracy were measured simultaneously.

The results indicated that as the number of bars increased, reaction times of the schizophrenic subjects increased less than the reaction times of the control subjects. Significantly faster reaction times for schizophrenic subjects ($p < .02$) were obtained independently of accuracy. Schizophrenic subjects were significantly faster than control subjects for five and six bar displays but did not differ significantly for three and four bar displays.

This result for control subjects could represent an increase in the time used to view the display globally as a hexagon and to view the five and six bar displays of the heterogeneous conditions. The faster reaction times for the schizophrenic subjects can be interpreted as indicating that schizophrenic persons tend to ignore the perceptual grouping conditions and the hexagon formation of the stimulus displays. Faster reaction times of the

schizophrenic subjects were therefore interpreted to mean that schizophrenic subjects were less engaged in task-irrelevant global processing than normal subjects, and therefore took less time to count the stimuli.

The present study provides support for a perceptual organizational deficit in schizophrenia.

Acknowledgements

I would like to express my gratitude to all the people who contributed to the completion of this dissertation. My most profound thanks go to my committee members Drs. Mitchell Kietzman, Rhea Dornbush and Wilma Winnick for their unfailing optimism, encouragement, and support. I would also like to thank Dr. Samuel Sutton and Dr. Daniel Caputo for their much appreciated comments, suggestions, and insights. Thanks also go to my computer programmers Dr. Craig Tenke, Dr. Philip Gasquoine, Dr. Harold Katcher, and Terry Jacobus, who made this experiment possible. I want to thank Gus Vargus and Stan Sham for their technical help. Sincere thanks also go to Dr. Philip Ramsey for his statistical assistance. I also want to thank my friends Merrell Gleimer and Saul Lichtine for helping in the preparation of this manuscript. I want to express my appreciation to New York Medical College and Westchester County Medical Center for allowing me to conduct research at their facility and to the psychiatrists, psychiatric aides, and secretaries who facilitated the completion of this research.

This dissertation is dedicated to my husband Dennis whose love and support helped me through this long gestation and to my daughter Altara who had no choice.

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PERCEPTUAL ORGANIZATION IN SCHIZOPHRENIA

Perceptual Organization

An object can be identified only when it is perceptually separated from its background. The perceptual segregation of figure and ground is the starting point for perceptual organizational processing (Haber & Hershenson, 1973) and must therefore occur early in processing so that correct identifications can be made. It has been suggested that in order to perceive a given object, organization of the perceptual field must occur to make the object the figure (Hochberg, 1973).

Early research in perception by Gestalt psychologists reported that perceptual organization is largely determined by the factors of similarity, proximity, continuation, closure, and common fate (Haber & Hershenson, 1973; Hochberg, 1973; Treisman, 1982). The law of similarity is defined as operating when groups are formed by elements which are similar to each other. The law of proximity is defined as operating when groups are formed by elements which are either spatially or temporally close to one another.

The Gestalt laws of good figure (Pragnanz principle) include the law of continuation, which is defined as occurring when the vector of a set of elements determines

the direction of the next element; closure, which is defined as the filling in or completion of an incomplete figure; and common fate, which is defined as being formed by objects which move or change together (Haber & Hershenson, 1973). A particular stimulus may have several of these laws acting in concert or in conflict (Hochberg, 1973).

In an investigation of the workings of these Gestalt principles, Beck (1972) proposed that figural properties produce similarity grouping before focal attention occurs. Similarity grouping is described as an acuity task involving simultaneous discrimination among stimulus differences which occurs prior to the more detailed focal attention processing. Discrimination of grouping and visual texture seem to be based on those properties of a display which are appreciated when attention is distributed over a large area (Beck, 1972). Perceptual grouping processes are thought to operate in parallel and are performed automatically without having to direct attention towards performing the grouping. Subsequent stages of processing should be affected by this preattentive organization (Treisman, 1982). In addition, impoverishment of the stimulus display by short tachistoscopic presentations, or reduced illumination causes an increase in the effect of Gestalt organizing forces (Hochberg, 1973).

Perceptual Organization of Schizophrenic Subjects

The hypothesis that schizophrenic persons respond differently from control subjects to perceptual organizational properties of stimuli (perceptual organizational deficit hypothesis) has recently been investigated in two experiments by Place and Gilmore (1980) using a perceptual span numerosity task. In their first experiment they employed both a "noise" condition and a "no noise" condition. The "no noise" condition consisted of from one to six lines positioned at the points of an imaginary hexagon. The "noise" condition consisted of from one to six lines and circles positioned at the points of an imaginary hexagon. The task of the subject was to respond to the number of lines presented so that in the noise condition the circles served as distractors. It was reported that the schizophrenic subjects were as accurate as the control subjects in the "no noise" condition. However, for schizophrenic subjects but not for control subjects, counting accuracy was significantly less for the "noise" condition than for the "no noise" condition.

These results of Place & Gilmore (1980) indicate that distracting and irrelevant elements adversely affect the performance of schizophrenic subjects when these elements need to be distinguished from other elements in

the visual display and ignored in order to perform the task. In the noise condition, the schizophrenic subjects did not appear to engage in global analysis and had difficulty perceiving the number of lines presented when the irrelevant circles were also present. The schizophrenic subjects apparently could not separate the lines and circles adequately enough to count only the lines. The control group, in comparison, is thought to have structured the stimulus information according to certain global properties such as similarity and proximity of the stimulus elements. Global analysis by the control subjects led to the perception of two distinct groups i.e., lines and circles. The control subjects were therefore able to count the lines more adequately.

Results of other studies have also suggested that schizophrenic subjects have difficulty ignoring irrelevant information (Saccuzzo, 1977). In comparison, there is evidence that when all the stimuli are relevant to the task, schizophrenic subjects do not exhibit a performance deficit (Cash, Neale, & Cromwell, 1972; Stillson & Kopell, 1964).

The perceptual organizational deficit hypothesis was explored further in Place and Gilmore's (1980) second experiment. This experiment was designed so that if the schizophrenic subjects were experiencing a perceptual

organizational deficit they would perform more accurately than the control subjects. Because all the stimuli in the display were relevant to the task, the different conditions of perceptual organization could only be distracting if the perceptual organization was noted.

In their second experiment Place and Gilmore (1980) presented stimulus displays of one to six lines in each of three distinct conditions of perceptual grouping (Homogeneous, Heterogeneous/Adjacent, and Heterogeneous/Nonadjacent conditions). In the Homogeneous condition only one group of either all horizontal or all vertical lines appeared. In the Heterogeneous/Adjacent condition lines of the same orientation were adjacent to each other, thus yielding two groupings. In the Heterogeneous/Nonadjacent condition multiple groupings of opposite orientation were possible. In all conditions the lines were positioned on the points of an imaginary hexagon. The subjects' task was to report the number of lines presented.

In Place and Gilmore's (1980) second study the number of lines presented were relevant to the task, but the orientation of the lines was irrelevant to the task. A decrement in performance due to the irrelevant line orientation variable occurred only for the control group but not for the schizophrenic group. The schizophrenic subjects' performance changed very little as the

conditions were varied from Homogeneous to Heterogeneous/Adjacent to Heterogeneous/Nonadjacent. In the Heterogeneous conditions, there was better overall counting accuracy for the schizophrenic subjects than for the control subjects. It is important to note however, that the control subjects in the Place and Gilmore (1980) study were drug abusing inpatients, not normal subjects.

Place and Gilmore (1980) used stimulus durations of 20 ms or less. In this explanation of the findings, it is assumed that exposure duration was too brief for schizophrenic subjects to organize and group the stimuli perceptually. In comparison, the control subjects exposed to similar stimulus durations, appeared to organize, i.e., to group the stimuli. Grouping is much more easily performed in the Homogeneous condition (laws of similarity and proximity) than in the heterogeneous conditions and therefore probably take less time. If less time is used for perceptual organization in the Homogeneous condition than heterogeneous conditions, more time is available for counting the number of bars presented. The perceptual organization of the stimulus displays leads to an interference with the accuracy of control subjects in the heterogeneous conditions.

It is hypothesized that in this task schizophrenic subjects do not analyze the visual input in a global manner. The schizophrenic subjects either failed to

perceive or tended to ignore the organizational features of the display. The schizophrenic subjects apparently did not notice the organizational differences so they were not distracted by them. This hypothesis of a perceptual organizational deficit is suggested because of the lack of any difference in counting accuracy for the schizophrenic subjects in the three perceptually distinct stimulus conditions. The organizational properties were distracting to the normal subjects and resulted in accuracy decrements for them from the Homogeneous to the Heterogeneous conditions, a type of continuum reflecting perceptual complexity. The irrelevancy of line orientation interferes with counting accuracy for the control subjects because they automatically organize the material perceptually. This perceptual organization (global analysis) requires time and since the stimulus exposure was brief the control subjects had insufficient time to accurately perceive the number of lines presented (Place & Gilmore, 1980).

The Place and Gilmore (1980) results suggest that schizophrenic persons do not respond to the organizational properties of stimuli in the same way as control subjects. Although the control subjects in the Place and Gilmore (1980) study were drug-abusing inpatients, a generalization of these conclusions to normal persons may be possible since the performance of

the drug-abusing inpatients was found to be comparable to the performance of normal college students obtained in a previous study by Place (nee Schwartz, 1978).

It is difficult to explain away the Place and Gilmore findings as resulting from a "generalized deficit" hypothesis since schizophrenic subjects performed at a higher counting accuracy than control subjects in the heterogeneous conditions. Better performance of schizophrenic subjects contradicts the "generalized deficit" hypothesis, since generalized deficit would predict poorer performance of schizophrenic subjects due to attentional or motivational factors (Kietzman et al., 1980).

In a partial replication of Place and Gilmore (1980), Wells and Leventhal (1984) found no significant differences in accuracy among the three perceptual grouping conditions for paranoid schizophrenic subjects as well as for nonparanoid schizophrenic subjects. In addition, Wells and Leventhal (1984) extended the findings of significant differences in accuracy among the three perceptual grouping conditions to nonschizophrenic psychiatric controls as well as to normal control subjects. Paranoid schizophrenic subjects, nonparanoid schizophrenic subjects, nonschizophrenic psychiatric controls, and normal controls were presented with the Place and Gilmore (1980) stimuli at a fixed exposure

duration of 15 ms. Accuracy scores decreased from the homogeneous to the heterogeneous conditions for the control groups. In comparison, accuracy scores did not differ between the homogeneous and heterogeneous conditions for the schizophrenic subjects. These results support the hypothesis that the schizophrenic subjects respond less than normal subjects to the Gestalt principles of similarity and proximity. Wells and Leventhal (1984) suggest that the schizophrenic subjects did not process the stimulus displays in the first stage (global processing) and only processed the information regardless of condition, in the second (detailed or local processing) stage of analysis.

Wells and Leventhal (1984) were unable to replicate the Place and Gilmore (1980) finding of significantly better overall accuracy for schizophrenic subjects. Although the groups in the Wells and Leventhal study did not differ in overall accuracy scores, the groups did differ in the way the accuracy scores were distributed in the three organizational conditions.

Additional support for the perceptual organizational deficit hypothesis is found in a more recent experiment of Wells and Leventhal (in press) employing x's and o's instead of lines as their stimulus elements. As was obtained in the Place and Gilmore (1980) and Wells and Leventhal (1984) studies, the controls' accuracy scores

were significantly higher for the Homogeneous condition than the Heterogeneous/Nonadjacent condition, while no such differences in accuracy were obtained for the nonparanoid schizophrenic subjects. This study provides further evidence to support the hypothesis that schizophrenic subjects do not respond initially to the global aspects of the displays as controls do. Schizophrenic subjects instead tend to perceive and process stimuli in a local, detailed manner.

Prior to the Place and Gilmore study (1980), several studies in the literature demonstrated performances by schizophrenic subjects which support the idea that schizophrenic patients have a problem in their perceptual organization. Evidence that schizophrenic subjects needed significantly longer stimulus exposure time to perceive correct groupings of stimulus elements was provided in a study by Kaswan (1958). This finding suggested that schizophrenic persons did not lack the ability but rather required significantly more time to perform perceptual groupings. This finding also implies that when schizophrenic subjects are exposed to short stimulus presentation durations and are not required to respond to perceptual groupings, organizational processing will be less likely to take place.

While Kaswan (1958) provided evidence that schizophrenic subjects take longer to perceptually

organize stimulus elements, evidence that such patients can profit from perceptual organization when the organization is made obvious, is provided in a study by Cox and Leventhal (1978). In their study, they employed enrichment conditions in which the available perceptual organization was made more emphatic. All groups showed improvement under this enrichment condition, but the process schizophrenic subjects improved more than the other groups on two of three tasks. The Cox and Leventhal (1978) data support the contention that process schizophrenic subjects (in their experiment, nonparanoid schizophrenic subjects) do not automatically organize their perceptual environments in the same way that controls or reactive schizophrenic subjects do (in their experiment, paranoid schizophrenic subjects). These data suggest that if a task does not require a subject to perform a global (wholistic) organization of the stimulus display in order to perform the task, schizophrenic subjects may be less influenced than normal subjects by the intrinsic organization.

Additional evidence that schizophrenic subjects engage more in local processing than in global processing comes from an unpublished doctoral dissertation by Siegal (cited in Snyder et al., 1961). Schizophrenic subjects were found to be more accurate than controls in adjusting the wings of the Muller-Lyer Illusion. This greater

accuracy apparently resulted from schizophrenic subjects' being less affected by the illusion. The schizophrenic subjects seemed to pay more attention to the parts of the illusion than the whole. The better performance of the schizophrenic subjects therefore reflects a deficit in overall perceptual organization.

Recent experiments by Frith and his colleagues (Frith, Stevens, Johnstone, Owens, & Crow, 1983; Griffith, Frith, & Eysenck, 1980) reported defective processing of faces by schizophrenic subjects. This deficit in the processing of faces was apparently due to the failure of wholistic (global) processing to dominate over the component elements making up the faces. In addition, Frith's results also suggest that some stimuli more readily elicit Gestalt processes than other, possibly less meaningful stimuli. According to Frith faces are more meaningful stimuli than nonsense figures or histograms. Performance of control subjects varied depending on which of the three types of stimuli were being sorted (faces, nonsense figures and histograms). The control subjects evidenced better sorting performance for the more meaningful stimuli. In comparison, the performance of the schizophrenic subjects did not vary with different types of stimuli being sorted. Frith et al. (1983) interpreted these results to be consistent with an inability of schizophrenic subjects to process

the environment in a global mannner.

All of these experimental results suggest that schizophrenic subjects are less likely to employ global processing. The schizophrenic subjects are also apparently less likely to be influenced by the laws of perceptual organization (laws of similarity, proximity, and good figure) unless the organization is emphasized and a necessary part of the task. The implication of these results is that schizophrenic subjects would be less likely to be influenced by the laws of perceptual organization in a task which requires ignoring the perceptual organization. Because normal subjects are believed to automatically engage in global processing, normal subjects should take longer than the schizophrenic subjects to perform a task which has an inherent perceptual organization. It is possible that normal persons are dominated by a need to perceive good figure even when the task does not require it. Since it is more difficult to perceive good figure in the more complex heterogeneous displays, normal subjects spend more time on the wholistic perception (even though not required for counting) and are therefore slower and less accurate for more complex heterogeneous displays.

Place and Gilmore (1980) suggested that the accuracy differences among the three organizational conditions reflected the greater time needed for processing the

increased number of groupings possible from the Homogeneous to the Heterogeneous/Adjacent to the Heterogeneous/Nonadjacent condition. Further research into this possibility failed to support this hypothesis. In a Masters' thesis using the Place and Gilmore (1980) stimuli, Lambert (1980) reported significant differences between the homogeneous and heterogeneous conditions, but obtained minimal differences between the two heterogeneous conditions. Lambert (1980) concluded that the total number of groups perceived did not appear to be the factor that led to interference in reporting the total number of lines. Accuracy failed to consistently decrease as the median number of groups for each display increased. The results of Lambert's (1980) study suggest that in normal controls the wholistic processing of the Homogeneous stimulus display is easier and therefore takes less time than the wholistic processing of stimuli with more than one grouping as in the Heterogeneous/Adjacent and Heterogeneous/Nonadjacent stimulus displays. Since more time would be spent in the wholistic processing stage, accuracy would be expected to decrease in the heterogeneous conditions because less time is available for counting.

Place and Gilmore (1980) explain their findings in terms of the similarity and proximity on the grouping of their line stimuli. However, because the lines were not

displayed at random, but rather were placed on the points of an imaginary hexagon, another type of Gestalt organization (good figure or Pragnanz principle) was also inherent in their displays. The imaginary hexagon was displayed in various forms of completion, and at five and six lines the hexagon was no longer imaginary. When three and four lines are presented good figure is not as strong a perceptual organizing force and therefore not as distracting as when five and six bars are presented. Global processing may be influenced differently for schizophrenic and normal subjects by this Pragnanz principle which involves closure and continuation.

Snyder, Rosenthal, and Taylor (1961) reported that chronic schizophrenic subjects displayed greater accuracy in performance due to a closure deficit (less closure), while acute schizophrenic subjects demonstrated a significantly greater degree of closure than normals (Snyder, 1961). Wells and Leventhal (in press) employed a closure task and obtained significantly less closure for the schizophrenic group than a combined psychiatric (other than schizophrenic) and normal control group, thus replicating the Snyder et al., (1961) finding of a closure deficit for chronic schizophrenic subjects. Snyder (1961) suggested that the closure deficit of the chronic schizophrenic subjects might represent an inadequacy of perceptual organizing systems in the brain

while the greater closure obtained with acute paranoid patients might represent an overactivity of the same perceptual organizing systems. Snyder (1961) suggested that the duration, severity, and subtype of schizophrenia influence perception.

Evidence indicates that there are marked differences in the way schizophrenic subjects and normal subjects perceptually process their environments. The present study has been proposed to explore differences in the timing of perceptual processing for normal control and schizophrenic subjects.

Rationale for Proposed Study

The present study attempted to replicate and extend the findings of Place and Gilmore (1980), who reported that accuracy decreased from the homogeneous to heterogeneous conditions for control subjects. An important question therefore raised by the Place and Gilmore study (1980) was whether increases in reaction time also occurred from the homogeneous to the heterogeneous conditions for control subjects. Increases in reaction time from the homogeneous to heterogeneous conditions would suggest differences in processing time among the conditions. While this question relates to the findings obtained with control subjects, an additional aspect of this question relates to the performance of the

schizophrenic subjects. Place and Gilmore and Wells and Leventhal reported, that schizophrenic subjects had comparable accuracy scores for the homogeneous and heterogeneous conditions. The question raised by this finding is whether schizophrenic subjects will respond with similar reaction times in the homogeneous and heterogeneous conditions. Comparable reaction times for the homogeneous and heterogeneous conditions would then seem to reflect processing time similarities between conditions for the schizophrenic subjects. These results of processing time differences between perceptual conditions for normal controls, but not for schizophrenic patients would indicate that processing time differences arise from perceptual organizational differences among the groups.

It is expected that certain aspects of the stimulus display will act as distractors, particularly for the normal controls, causing more time to be spent in the global processing stage because of the increasing perceptual organizational demands of the stimuli. These perceptual organizational aspects are: The increased number of perceptual groupings from the Homogeneous to the Heterogeneous/Adjacent and Heterogeneous/Nonadjacent conditions; and the increased likelihood that a hexagon is perceived because more corners of the hexagon contain elements.

Research on the perceptual organization of normal subjects (e.g., Beck 1972; Hochberg, 1973; Treisman, 1982) seems to suggest that as long as Gestalt organizing forces are contained within the stimulus display, global processing will be initiated, at least initially. Research with normal subjects also suggests that global processing appears to be automatic and occurs before the local, more detailed analytic processing (e.g., Knight, 1983; Kroll & Hershenson, 1980; Phillips, 1974; Potter, 1976).

In the present study it is believed that normal subjects will be affected by the perceptual organizational elements even though these organizational elements are irrelevant to performance of the task. It is expected that control subjects will display increased reaction time and decreased accuracy as the number of perceptual groupings increased from the Homogenous to Heterogeneous/Adjacent and Heterogeneous/Nonadjacent conditions. It is suggested that whether the perceptual organization of bars is inherent in the stimulus display as in the Heterogeneous/Adjacent condition, or determined by the subject when more than two perceptual organizations are possible as in the Heterogeneous/Nonadjacent condition, more time is being used than when only one grouping of bars is presented (Homogeneous condition). Although the number of groupings

per se may not be related to the Place and Gilmore (1980) accuracy differences (Lambert, 1980), it is possible that the increased number of groupings in the Heterogeneous/Adjacent and Heterogeneous/Nonadjacent conditions than in the Homogeneous condition make it more difficult to perceive good figure. The ease with which the laws of perceptual organization may be implemented may be the cause of the accuracy differences among the conditions. The Heterogeneous conditions would seem to require the most time to be perceptually organized by the normal subjects as the number of bars are increased. Because the Heterogeneous/Nonadjacent condition appears to be the most difficult display in which to perceive similarity, proximity, and good figure, this condition should give the least accurate numerosity judgements and the longest reaction times.

Reaction time is expected to increase and accuracy decrease as the number of bars presented increase (perceptual span effect). When reaction time is measured in a perceptual span experiment, it is found to increase gradually as the number of stimulus elements to be perceived is increased (Woodworth & Schlosberg, 1954). This gradual increase in reaction time to increases in the number of elements presented is what is expected from the contribution of the perceptual span effect alone, without the contribution of closure, continuity, and

common fate factors. It has been demonstrated in previous studies that threshold variations, perceptual grouping, previous learning, practice, and stimulus characteristics of intensity and duration affect the perceptual span (Hunter & Sigler, 1940; Woodworth & Schlosberg, 1954). It is therefore suggested that the perception of a hexagon, particularly at five and six bars when the perception of a hexagon is most prevalent, will foster global processing. The global processing of the closure factors should be more difficult for the more complex condition (Heterogeneous/Nonadjacent) and therefore slow down closure. The control subjects are expected to respond to increases in the number of bars presented with reaction times which reflect two factors: (1) the generally obtained baseline levels for perceptual span (Woodworth & Schlosberg, 1954) and; (2) the additional time used to globally process the closure, continuation and common fate of the hexagon. These perceptual forces of organization (good figure) will cause the greatest perceptual organizational demands on the six bar condition since these organizational factors would be most disruptive on the counting task when their influence is strongest and most commanding for wholistic processing.

In the present experiment, the duration of the stimulus display is fixed at 33 ms. The subject cannot

therefore compensate for additional perceptual elements with a longer duration of the display. It is expected that as the conditions become more complex (Homogeneous to Heterogeneous/Adjacent to Heterogeneous/Nonadjacent) and the number of bars presented increase, decreased accuracy in addition to longer reaction times, will result.

If the perceptual organizational ability of the elderly normal subjects is intact, their reaction time and counting accuracy should be more similar to those obtained with the young normal subjects. Similar performances of the elderly to those of the young controls would result in an increase in reaction time and a decrease in counting accuracy as the number of perceptual groupings increases from the Homogeneous condition to the Heterogeneous/Adjacent condition to the Heterogeneous/Nonadjacent condition. In addition, the elderly would also be expected to respond with greater increases in reaction time than schizophrenic subjects for five and six bars than to three or four bars due to the tendency to view the display globally as a hexagon.

In summary, research investigating the perceptual organization of schizophrenic patients (e.g., Frith et al., 1983; Kaswan, 1958; Place & Gilmore, 1980; Wells & Leventhal, 1984 & in press) suggests that these subjects are less likely than controls to be influenced by the

laws of perceptual organization and therefore less likely to engage in global processing. The schizophrenic subjects are expected to be less influenced than control subjects by the increased number of perceptual groupings from the Homogeneous to Heterogeneous/Adjacent to Heterogeneous/Nonadjacent conditions. The schizophrenic subjects are also expected to be less influenced than control subjects as the display more closely approximates a hexagon. Evidence indicates that perceived numerosity is serially processed (Lorenstein & Haber, 1975) and schizophrenic subjects are thought to perform adequately in serial processing tasks (e.g., Cash et al , 1972). If the schizophrenic subjects are not influenced or less influenced by the completeness of the hexagon, it is expected that these subjects will display only the characteristic gradual increase in reaction times generally obtained in perceptual span experiments (Woodworth & Schlosberg, 1954). The reaction times of schizophrenic subjects may therefore actually become faster than those of normal subjects with increases in the number of bars.

The faster reaction times of the schizophrenic subjects may mean that they are not spending as much additional time as normals in processing the figure globally. If the perceptual grouping features of the display do not act as distractors for the schizophrenic

subjects, it is expected that they will perform with similar reaction times in the three perceptual grouping conditions (Homogeneous, Heterogeneous/Adjacent, and Heterogeneous/Nonadjacent).

Schizophrenic subjects are expected to respond with faster reaction times than control subjects as the number of bars increase. These faster reaction times of the schizophrenic subjects would then appear to be due to a deficiency in the global processing of the three perceptual grouping conditions in interaction with the formation of the hexagon. If schizophrenic subjects are less influenced by the Gestalt properties and therefore do not engage in global processing while normal subjects do, the task should take less time for schizophrenic than normal subjects. Faster reaction times of the schizophrenic subjects could be interpreted to be the result of ignoring the perceptual organization of the stimulus arrays. Such results would also suggest the absence of any "generalized deficit" for the schizophrenic subjects because their performance was better (faster reaction times) than the young normal subjects.

Rationale for Subject Selection

The present experiment included three groups of subjects: newly admitted schizophrenic patients, young

normal controls, and elderly normal controls. When comparing the performance of schizophrenic subjects to that of young normal subjects, differences between these two groups are generally obtained with schizophrenic subjects performing more poorly and with slower reaction times than controls on most psychological tasks (Kietzman & Sutton, 1977; Kietzman, et al., 1980; Lawson, McGhie, & Chapman, 1967; Russell, Consedine, & R.G. Knight, 1980).

When comparing results for young normal and elderly normal subjects, the elderly are found to be more distractible, experience difficulty in ignoring irrelevant material, require longer minimum stimulus exposure time, exhibit longer reaction times with a 20% difference in reaction time between 20 year old subjects and 60 year old subjects (Birren, Woods, & Williams, 1980), and perform significantly more poorly on perceptual closure tasks (in terms of a reduced ability to organize in a completion task and also a reduced ability to resist closure in a concealed figures task) than young normal subjects (Basowitz & Korchin, 1957; Schonfield, 1974).

Some of the psychological deficits observed in an elderly population have been found to parallel deficits in a schizophrenic population. The similarities between the schizophrenic and elderly normal subjects include: slowness of response, a need for longer stimulus exposure

durations, motivational difficulties, lack of interest, susceptibility to distraction, and a difficulty in ignoring irrelevant information (Brody, Saccuzzo, & Braff, 1980; Saccuzzo, 1977).

The use of these three groups may allow us to shed light on the nature of the processing differences between normal controls and schizophrenic subjects. Will the elderly controls respond to the perceptual complexities in the same way as the young controls do, but perhaps with longer reaction times, or will the elderly controls respond to the perceptual complexities in the same way as the schizophrenic subjects do?

Rationale for Selection of Behavioral Measures

Two types of behavioral measures are typically employed in perceptual span experiments: counting accuracy and reaction time. Some perceptual span experiments have measured only counting accuracy (Lambert, 1980; Place & Gilmore, 1980; Schwartz, 1978; Wells & Leventhal, 1984), whereas other perceptual span studies have measured reaction time in addition to the usual counting accuracy measures (Oyama, Kikuchi & Ichihara, 1981; Saltzman & Garner, 1948).

Reaction time has been reported to be the most direct and economical measure for studying perceptual span. Saltzman and Garner (1948) used 2-10 concentric

rings to study the numerosity perceptual span. They carried out two experiments, one using counting accuracy as the measure and a second using reaction time as the measure.

Counting accuracy was found to improve with repetition. Repeated practice had an effect on the accuracy of the smaller number of circles, but little effect on the accuracy of report of 6-10 circles. In comparison, reaction time was reported to increase steadily with increases in the number of circles presented. Repetition led to a small decrease in reaction time for the first five out of 10 sessions. Saltzman and Garner (1948) concluded that reaction time measures were superior to counting accuracy measures. This conclusion was based on findings indicating that clear differences in reaction time were obtained even after long practice and the total range of the number of circles was known to the subject, and that the reaction time method produced a higher reliability of results in less time than the accuracy measure alone.

The present study examined the numerosity perceptual span in schizophrenic patients and in two groups of nonpatients (young and elderly), using counting accuracy and reaction time as response measures. It was predicted that as the number of perceptual groupings increased from the Homogeneous to the Heterogeneous/Adjacent and

Heterogeneous/Nonadjacent conditions and the tendency to see the display globally as a hexagon increased as the number of bars increased, decreased counting accuracy and increased reaction time would result for nonpatients but for schizophrenic subjects these measures would remain constant.

Method

Subjects

All potential subjects (schizophrenic and controls) were given an initial screening interview in order to eliminate those subjects who were drug abusers, had less than 20/30 acuity, were on daily medications with potential psychological effects (other than the medications given to schizophrenic subjects), or had evidence of organicity. The potential subjects were also interviewed using The Schedule for Affective Disorders and Schizophrenia Life Form (SADS-L; Endicott & Spitzer, 1978) by the author, in order to determine if psychopathology was present (stringent inclusion and exclusion criteria are listed in Appendix A). If psychopathology was present, diagnosis was determined according to the Research Diagnostic Criteria (RDC; Spitzer, Endicott, and Robbins, 1978). The entire interview required approximately 30 minutes to one hour.

Patient group. Ten acute-care, recently admitted schizophrenic subjects, aged 18-45 participated in the present experiment. Of the fifteen schizophrenic subjects who were screened and accepted for participation in the present study, only ten were able to complete the experiment (one subject could not stay in a dimly lit room, two subjects could not keep their eyes open because

of their medication, one subject was too psychotic to finish the experiment and one subject could not count the bars even without filters). These subjects were recently admitted inpatients whose maximum stay at the Westchester County Medical Center Psychiatric Hospital was generally limited to two to four weeks. A diagnosis of schizophrenia was made at the hospital by the attending psychiatrist in accordance with the DSM-III. Table 1 describes the characteristics of the schizophrenic population.

Since there is some indication in the literature that anti-psychotic medication decreases reaction time in normal subjects (Stone, Callaway & Jones, & Gentry, 1969) and that schizophrenic patients may be similarly affected by the medication (Braff & Saccuzzo, 1982), the first testing session for schizophrenic subjects was performed within 72 hours after anti-psychotic medication was initiated to minimize any possible effects due to the anti-psychotic drugs (Range = 3 to 72 hours; Mean = 31 hours, Std. Dev. = 27).

Schizophrenic subjects (see Table 2) received from 120 mg to 2250 mg chlorpromazine equivalent dosages (Appleton, 1982). One subject was not given any medication prior to the first testing session. All patients, with the exception of one, had been off anti-psychotic medication (taken prior to the current

Table 1

Characteristics of schizophrenic subjects

Patient	Paranoid (P) Nonparanoid (NP)	# Hospitalizations	Total time hospitalized (mos.)
CR	P	4	< 3 mos.
JH	P	1	< 1 mo.
RT	P	2	< 3 mos.
WN	NP	2	< 3 mos.
TE	P	2	< 12 mos.
TA	NP	2	< 24 mos.
LV	P	4	< 12 mos.
DO	NP	1	< 1 mo.
PW	NP	1	< 1 mo.
GL	NP	4	< 24 mos.

Table 2

Medications (per day) of schizophrenic subjects at the first and second testing sessions.

PATIENT	MEDICATION 1ST SESSION	MEDICATION 2ND SESSION
WN	100mg. Thorazine QID.	Same
RT	NONE	2cc. Prolixin decanoate
JH	10mg. Navane BID.	-----
CR	5mg. Haldol 1 dose	-----
TA	5mg. Haldol QID.	Same
DO	5mg. Haldol TID.	10-15-20mg. Haldol
TE	10mg. Prolixin HCL QID.	40mg. Prolixin HCL
GL	10mg. Haldol TID.	Same
PW	10mg. Haldol TID.	15mg. Navane TID.
LV	2mg. Stelazine TID.	Valium

hospitalization) for a minimum of one and a half months. One patient had been off anti-psychotic medication for two and a half weeks.

Subjects who met RDC for any of the following subtypes of schizophrenia were included in the study: Paranoid, Disorganized, Catatonic, Undifferentiated, Residual, or Schizophreniform. An agreement between the RDC diagnosis and the psychiatrist's DSM-III was necessary for inclusion in the present study.

In addition, a person who had displayed manic or depressive symptoms at least three months prior to the present schizophrenic episode but was no longer presenting significant manifestations of affective illness were assumed to be schizophrenic (See Appendix A for RDC of schizophrenia).

Any patients with a diagnosis other than that of Schizophrenia or Schizophreniform (Schizophrenia with less than six months of symptoms) were excluded from the study. Thus, those diagnosed as schizo-affective were excluded. (See Appendix A for exclusion criteria and RDC of the schizo-affective disorder).

The patients were paid for their participation, excluding the screening interview, at the rate of \$10 for each testing session.

Control groups. The control subjects were obtained by advertisements on bulletin boards, Pennysaver ads, and

by canvassing Senior citizen groups.

Ten normal control subjects age matched to the schizophrenic patients and 10 normal elderly control subjects whose ages ranged from 60 to 72 years were tested. Eleven young subjects were screened and accepted for participation. One subject was later found to be a cocaine abuser and therefore eliminated from the study. Eleven elderly subjects were also screened and accepted for participation. One subject was unable to activate the microphone of the voice key. The younger normal group and the schizophrenic group were matched with respect to educational level, race, and sex. The elderly normal subjects were all Caucasian, but otherwise matched the schizophrenic group in educational level and sex (see Table 3).

Control subjects were paid for their participation, excluding the screening interview, at the rate of \$10 for each testing session.

Apparatus and Stimuli

The experimental stimuli were presented by a TRS-80 (Radio Shack) Model I microcomputer. The stimuli were displayed on a video monitor, which is a cathode-ray tube that is similar in appearance to a 12 inch television screen. The subjects were seated at a table on which a

Table 3

Matching characteristics of the schizophrenic, young control, and elderly control subjects.

GROUP	RACE	AGE (yrs.)	EDUCATION (yrs.)	SEX

Schizophrenic				
CR	B	25	11	F
JH	C	37	19	M
DO	B	29	12.5	F
RT	B	36	12.5	F
WN	H	22	14	M
TE	C	23	12.5	M
LV	C	21	12	F
PW	B	29	12.5	F
GL	C	28	12	M
TA	C	36	13	M
		MEAN=28.6	MEAN=13.1	
		SD=6.02	SD=2.21	
Young Controls				
IS	H	26	12	M
VA	C	36	14	F
CM	C	28	13	F
GB	B	25	12	M
FP	C	24	14	F
AS	C	34	16	F
JG	C	20	12	M
JT	B	29	14	F
DB	B	20	13.5	M
BG	B	35	12	M
		MEAN=27.7	MEAN=13.25	
		SD=5.83	SD=1.32	
Elderly Controls				
TC	C	61	14	F
FA	C	70	9	M
TW	C	66	18	M
AB	C	65	14	F
JG	C	63	12	M
PB	C	63	12	M
BG	C	60	16	F
CH	C	67	11	F
PL	C	63	14	M
MG	C	72	12	F
		MEAN=65	MEAN=13.2	
		SD=3.83	SD=2.57	

C = Caucasian B = Black H = Hispanic

chin rest was positioned so that the viewing distance between the subject and the screen was 27 inches. At this distance, adjacent points of an imaginary hexagon (on which the stimulus bars to be presented were positioned) were approximately one degree apart. The entire display subtended a visual angle of 2.37 degrees. Each bar was 8 mm long and 4 mm wide.

A microphone was positioned under the subject's mouth and attached to the chin rest. The microphone was interfaced with a port system from Alpha Electronics for the computer to register the voice activated reaction time. All measurements of time, including stimulus exposure duration, intervals, and responses was done by the microcomputer.

The testing room was illuminated by a 12V, high intensity bulb (#93) so that an ambient, mesopic lighting condition was created.

The intensity to be used for the stimulus display was determined for each subject by a threshold procedure. Kodak neutral density wratten filters (#96) ranging from 0.0 to 2.8 were used to change the intensity of the stimulus display. In the absence of the filters little contrast existed between the bars and their background. The filters were placed in a holder which allowed for quickly changing the filter density combinations. The holder sat on top of the computer monitor and allowed the

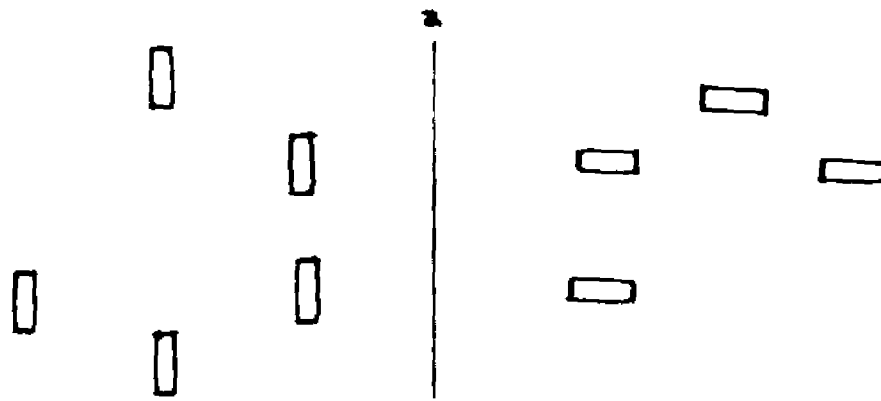
filters to sit in front of the two inch square hole in a black plastic screen which covered the face of the computer monitor.

The subjects were exposed to three conditions of perceptual organization involving the presentation of horizontal and vertical bars of light, which increased in perceptual organizational complexity from a Homogeneous condition (H) to a Heterogeneous/Adjacent condition (HA) to a Heterogeneous/Nonadjacent (HNA) condition, similar to those used by Place and Gilmore (1980). The bars were placed on adjacent points of an imaginary hexagon. The hexagon became more apparent as the number of bars presented increased. In the Homogeneous condition (Figure 1a) the bars formed one group, either all horizontal or all vertical. In the Heterogeneous/Adjacent condition (Figure 1b) the bars formed two groups, horizontal bars adjacent to vertical bars. In the Heterogeneous/Nonadjacent condition (Figure 1c) the bars formed more than two groups of alternating horizontal and vertical bars.

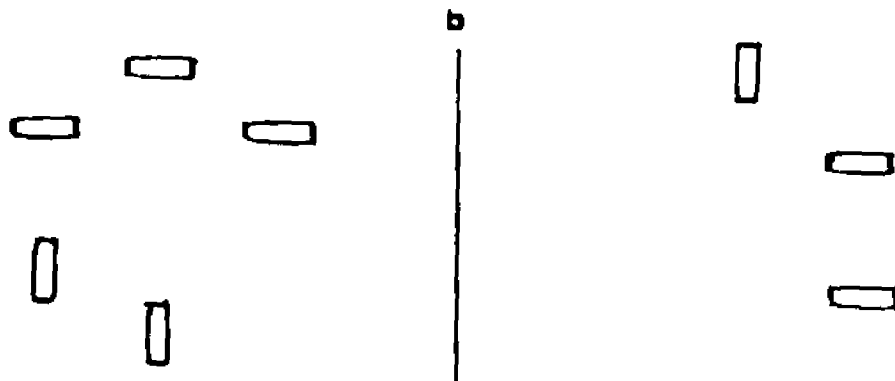
FIGURE 1. Examples of stimulus configurations.

- 1a. Homogeneous condition.
- 1b. Heterogeneous/Adjacent condition.
- 1c. Heterogeneous/Nonadjacent condition.

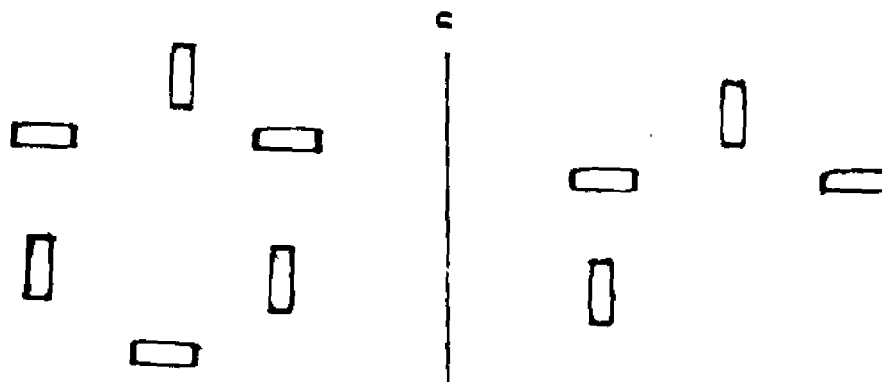
Figure 1
Homogeneous



Heterogeneous/Adjacent



Heterogeneous/NonAdjacent



Procedure

All subjects were tested at The Psychiatric Institute of Westchester County.

Subjects participated in two sessions. The time between the first and second sessions was determined by each patient's admission and release from the hospital, since testing occurred at these two times. The control subjects were tested on a time-matched schedule.

In each session both the threshold determination procedure and the main experiment were carried out.

Before the threshold procedure began subjects were asked to identify vertical and horizontal bars in order to insure that they had an understanding of what was meant by vertical and horizontal. This was done in accordance with the Place and Gilmore (1980) procedure.

Instructions were read to all subjects before the discrimination threshold determination and then read again before the main experiment (see Appendix B for instructions) in both sessions. Subjects were instructed to respond with both speed and accuracy. Responses were spoken into a voice key. The voice key was interfaced to the computer for registration of reaction time. The reaction times and the codes to the various stimulus displays were presented on the video monitor after each trial, and were recorded by the experimenter for future analysis. Accuracy responses were recorded by the

experimenter. The subjects were unable to view the results.

The stimulus intensity to be used for each subject was determined by an adaptive threshold procedure (Bruder, Sutton, Babkoff, Gurland, Yozawitz, & Fleiss, 1975). In this procedure, Kodak wratten filters were placed in front of the stimulus display to obtain a 60%-70% counting accuracy level. The filters were adjusted to either increase or decrease the intensity of the stimulus display depending upon the subject's accuracy in each block of three trials. If the subject was correct on all three trials the density of the filters was increased. If the subject was correct on two of the three trials, the filter density remained the same for the next block. If the subject was only correct on one of the three trials, the filter densities were decreased. An attempt was made to represent the three different perceptual organization conditions in each block.

Threshold determination - both sessions. One to six bars were presented on each trial in the threshold procedure. The duration of the stimulus display was 33 milliseconds. This duration was the minimum time required for the display to be presented on the video monitor without errors in transmission (Lincoln & Lane, 1980).

The criteria for stopping at a particular filter

were two blocks with a mean counting accuracy of between 60%-70% correct, the best filter obtained after a maximum of 45 minutes, or three blocks at the same filter with a counting accuracy of 60%-70% correct if these were the first three blocks of the session.

The stimulus display occurring on each trial in the threshold procedure was selected from a quasi-randomized data statement containing the following possibilities: One to six bars for the Homogeneous condition; two to six bars for the Heterogeneous/Adjacent condition; and three to six bars for the Heterogeneous/Nonadjacent condition.

Main experiment - both sessions. Each subject was tested for 144 trials in a one to two hour session; each of 12 different stimuli were presented 12 times. In each condition three to six bars were presented in four blocks consisting of 36 quasi-randomized trials in each. If the subject did not respond within three seconds from the offset of the stimulus display or if the subject missed the display, then that trial was put at the end of the trials to be presented. This was necessary to prevent the loss of data.

Each block contained three of each of the 12 possible stimuli. The 12 stimuli consisted of four Homogeneous stimuli (three to six bars), four Heterogeneous/Adjacent stimuli (three to six bars), and four Heterogeneous/Nonadjacent stimuli (three to six

bars). The subjects were given a brief rest between blocks.

In the main experiment, as in the discrimination threshold procedure, each trial began with the Experimenter saying the word "Ready" and initiating the trial by pressing the space bar key of the microcomputer. A fixation dot was present for a variable duration of between 1500-3000 ms. When the fixation dot disappeared, the bars were flashed on the screen for the 33 ms. The time between the offset of the bars until the reappearance of the fixation dot was 4000 ms. The reappearance of the fixation dot indicated that the next trial was ready to begin. The task of the subject was to respond as rapidly as possible when the bars were flashed, by calling out the number of bars seen into a voice key. The initial testing session for each subject was completed in a one and a half to three hour session (see Table 4).

Retesting. A second testing was carried out to determine whether performance under the three conditions of perceptual organization would change as a result of the clinical remission of schizophrenic symptoms and/or the medication regime. Retesting was completed in a one to two hour session (see Table 4) and could be carried out on most but not all of the subjects in the three groups.

Table 4

Amount of time (in minutes) taken to complete the first and second sessions.

GROUP	FIRST SESSION	SECOND SESSION
Schizophrenic	MEAN=96.5 SD=25.37 N=10	MEAN=85.75 SD=16.53 N=8
Young Controls	MEAN=78.7 SD=15.68 N=10	MEAN=73.3 SD=7.38 N=9
Elderly Controls	MEAN=71.78 SD=6.00 N=10	MEAN=73.11 SD=8.13 N=9

The schizophrenic subjects were retested before being released from the hospital. Two of the 10 schizophrenic subjects were unavailable for retesting since notification of their impending release came too late before discharge. Normal subjects were also retested in a session which was matched in time to the retesting of the schizophrenic subjects. This retesting was done in order to determine whether changes in performance occurred as a result of being retested. One young control and one elderly control were also unavailable for retesting. Retesting generally occurred from one to four weeks after the initial testing (Mean = 16 days, Sd = 6.6).

Results

Thresholds

Mean filter densities obtained for the three groups of subjects are presented in Table 5. This table shows young control subjects used denser filters than either the elderly controls or schizophrenic subjects. Both the schizophrenic and normal elderly groups required significantly more light in the stimulus display than the young normal group in order to attain a similar initial discrimination, ($F(2,27) = 4.9226, p < .05$) in the first session. This relationship remained when thresholds were obtained at the second testing, ($F(2,23) = 4.0997, p < .05$).

Data Analysis

In order to insure normality and equal variances, both the accuracy data and reaction time data were transformed (Winer, 1962). An arc sin transformation was performed on each accuracy score while a logarithmic transformation (Base 10) was performed on each reaction time score. Separate F-MAX tests (Winer, 1962) were performed on the transformed accuracy and reaction time data. No significant differences for total group variance were obtained for accuracy or reaction time among the schizophrenic, young normal or elderly normal subjects.

Table 5

Mean filter densities of Kodak wratten filters (#96) obtained for the three groups of subjects.

GROUP	1ST SESSION	2ND SESSION
Schizophrenic	MEAN=1.74 SD=.61 N=10	MEAN=1.84 SD=.83 N=8
Young Controls	MEAN=2.34 SD=.20 N=10	MEAN=2.49 SD=.13 N=9
Elderly Controls	MEAN=1.77 SD=.54 N=10	MEAN=1.96 SD=.34 N=9

The degrees of freedom in all ANOVAS were adjusted using the Huynh-Feldt epsilon correction. In order to protect against a Type I error in a repeated-measures analysis, epsilon is estimated from the samples' variance-covariance matrix and the degrees of freedom are adjusted accordingly (Jennings & Wood, 1976).

A summary of the significant effects obtained in the different analyses for accuracy and reaction time are presented in Tables 6 and 7, respectively.

All main effects were further analyzed using a Shaffer-Welsch paired comparison test (Ramsey, 1981; Welsch, 1977). The alpha level accepted was selected at $p=.05$. Interactions were further analyzed using a priori contrast paired comparison tests for planned comparisons and a Scheffe for all other interactions (Ramsey, 1981). The acceptable level of significance for the a priori was $p<.05$ (Welsch, 1977) and for the Scheffe was $p<.10$ (Edwards, 1972).

Analysis of First and Second Sessions.

Accuracy. The proportion correct for the first and second sessions are presented in Table 8. Inspection of the table shows the schizophrenic group to have poorer accuracy scores than either the young or elderly control subjects. A five-way analysis of variance of accuracy scores (group x block x number of bars x condition x

Table 6

Summary table of significant accuracy effects.

Source	5-WAY	REPORTED # BARS
G	**	
A		
A x G	**	
B	**	**
B x G		
A x B		
A x B x G		
C	**	
C x G		***
A x C		
A x C x G		
B x C		
B x C x G	**	
A x B x C		
A x B x C x G		
D	**	
D x G		
A x D		
A x D x G		
B x D		
B x D x G		
A x B x D		
A x B x D x G		
C x D		*
C x D x G		
A x C x D		
A x C x D x G		
B x C x D		
B x C x D x G		
A x B x C x D		
A x B x C x D x G		

Key to Table

A	:	Blocks	*	p<.05
B	:	Number of bars	**	p<.01
C	:	Condition	***	p=.05
G	:	Group		
D	:	Session		

Epsilon corrected.

Table 7

Summary table of significant reaction times.

Source	COMPARABLE		ACCURACY	CORRECT ANSWER RTS
	5-WAY	1ST SES 4-WAY	2ND SES 4-WAY	
G				
A			*	
A x G				
B	**	**	**	**
B x G	**	*		***
A x B				
A x B x G				
C	**	**		*
C x G				
A x C				
A x C x G				
B x C	**			
B x C x G				
A x B x C				
A x B x C x G	*		**	
D	**			
D x G				
A x D				
A x D x G				
B x D	**			
B x D x G				
A x B x D				
A x B x D x G				
C x D	**			
C x D x G				
A x C x D				
A x C x D x G				
B x C x D				
B x C x D x G				
A x B x C x D				
A x B x C x D x G				

Key to Table

A	:	Blocks	*	p < .05
B	:	Number of bars	**	p < .01
C	:	Condition	***	p < .07
G	:	Group		
D	:	Session		

Epsilon corrected.

Table 8

Mean proportion correct for the three groups of subjects for the different conditions and different number of bars presented in the first and second sessions.

		FIRST SESSION											
		H				HA				HNA			
		3	4	5	6	3	4	5	6	3	4	5	6
<hr/>													
GROUP													
S													
MEAN		.50	.40	.51	.30	.55	.40	.46	.21	.54	.45	.41	.17
SD		.35	.21	.30	.25	.29	.28	.28	.29	.29	.26	.37	.15
Y													
MEAN		.82	.81	.80	.81	.81	.76	.77	.70	.85	.66	.78	.70
SD		.16	.22	.15	.13	.19	.16	.14	.18	.22	.19	.16	.20
E													
MEAN		.84	.86	.70	.66	.80	.75	.65	.62	.79	.64	.75	.55
SD		.16	.14	.17	.20	.15	.21	.24	.25	.10	.19	.19	.26

		SECOND SESSION											
		H				HA				HNA			
		3	4	5	6	3	4	5	6	3	4	5	6
<hr/>													
S													
MEAN		.71	.55	.53	.43	.60	.56	.51	.29	.63	.38	.50	.24
SD		.35	.30	.26	.26	.36	.29	.27	.25	.38	.30	.28	.19
Y													
MEAN		.76	.61	.56	.63	.76	.69	.65	.57	.66	.63	.64	.41
SD		.22	.18	.17	.12	.19	.19	.13	.18	.20	.18	.17	.19
E													
MEAN		.79	.75	.67	.61	.78	.70	.62	.59	.74	.67	.59	.47
SD		.18	.20	.21	.30	.15	.24	.23	.32	.21	.24	.20	.30

S=Schizophrenics Y=Young controls E=Elderly controls

session) revealed significant main effects of groups (measured in proportion correct), ($p < .005$); number of bars, ($p < .0001$); conditions, ($p < .0001$); and session, ($p < .001$). Two significant interactions were also obtained in this analysis: A group by block interaction, ($p < .05$) and a group by condition by number of bars interaction, ($p < .005$). A summary of the analysis of variance is presented in Appendix C.

The group differences in accuracy were due to the schizophrenic subjects performing with significantly less accuracy than either the young normal or elderly normal subjects ($p < .05$). Pairwise multiple comparisons for the number of bars presented revealed that as the number of bars in the display increased, the number correct significantly decreased ($p < .05$), with the exception that accuracy for four and five bars did not differ significantly from each other. Pairwise multiple comparisons for the three perceptual organizational conditions revealed that accuracy decreased significantly ($p < .05$) from the Homogeneous condition to the Heterogeneous/Adjacent condition to the Heterogeneous/Nonadjacent condition. The main effect of session indicated significantly reduced accuracy in the second session ($p < .05$).

Post hoc tests revealed that the group by condition by number of bars interaction was due to schizophrenic

subjects, but not control subjects, significantly decreasing in accuracy from five to six bar displays in the Heterogeneous/Adjacent condition ($F(12,138) = 2.6367$), $p < .01$ and Heterogeneous/Nonadjacent condition ($F(12,138) = 3.0083$), $p < .01$ (see Figure 2).

Reaction time. The mean reaction times for the first and second sessions are presented in Table 9. Inspection of the table show faster responses for schizophrenic than control subjects for five and six bar displays.

A five-way analysis of variance (block x group x number of bars x condition x session) found significant main effects for number of bars, ($p < .0001$); condition, ($p < .0001$); session, ($p < .0001$). Five significant interactions were also obtained in the analysis, condition by session ($p < .0001$); number of bars by session, ($p < .01$); number of bars by condition, ($p < .01$); a group by number of bars interaction, ($p < .005$); and a four way group by block by number of bars by condition interaction, ($p < .05$). This analysis of variance is summarized in Appendix D.

A post hoc analysis revealed the perceptual span effect; as the number of bars increased, reaction time increased significantly ($p < .05$). The main effect of session was due to significantly faster reaction times in the second testing session.

Figure Caption

Figure 2. Group by condition by number of bars interaction in accuracy for the combined first and second sessions for eight schizophrenic, nine young control, and nine elderly control subjects.

Solid lines represent the Homogeneous condition

(●————●).

Broken lines represent the Heterogeneous/Adjacent

condition (●— — — — —●).

Large and small broken lines represent the

Heterogeneous/Nonadjacent condition (●-----●).

Schizophrenic subjects = diamond (◇).

Young normal subjects = cross (⊕).

Elderly normal subjects = square (□).

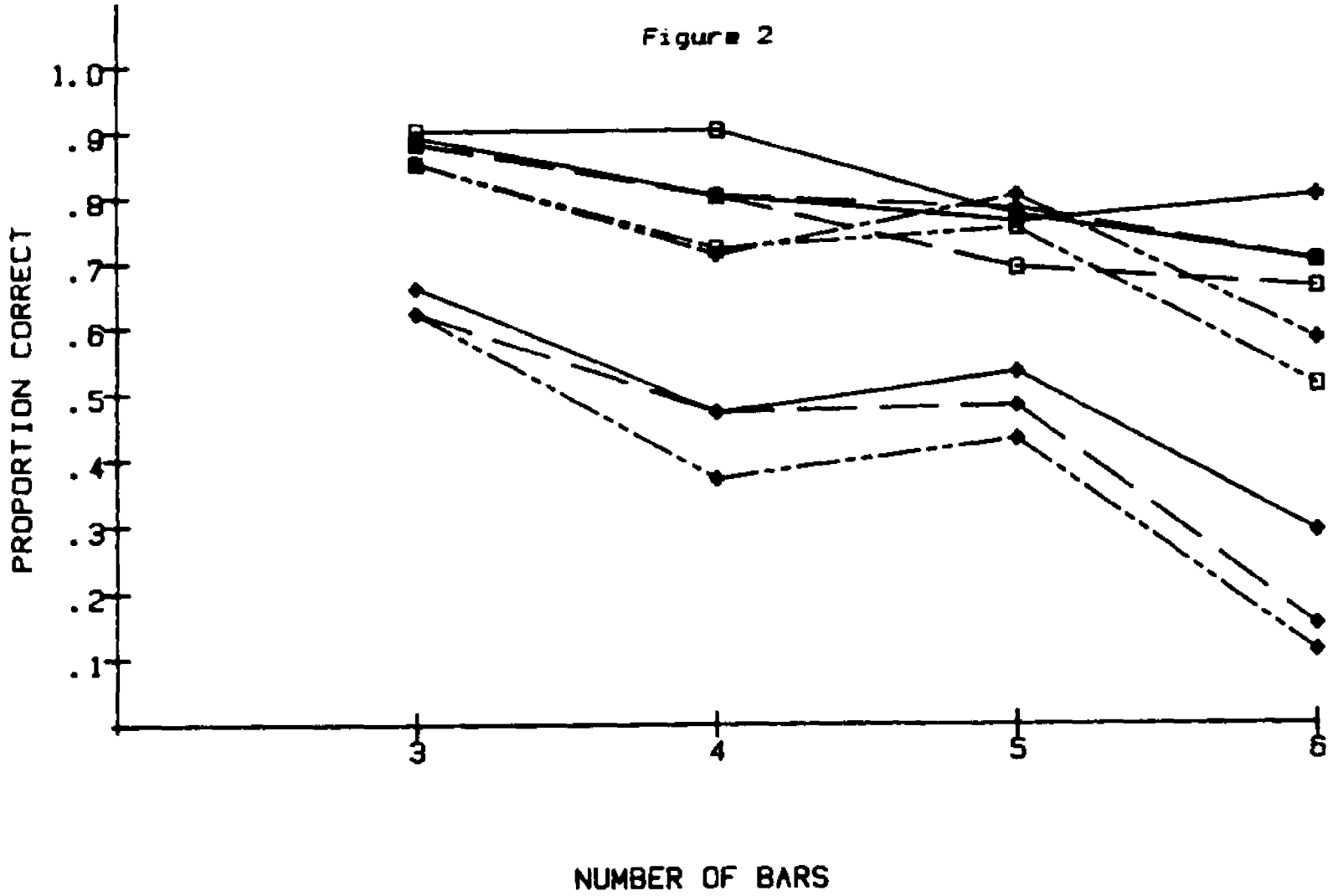


Table 9

Mean reaction times (ms) for the three groups of subjects for the different conditions and different number of bars for the first and second sessions.

	FIRST SESSION											
	3	4	H 5	6	3	4	HA 5	6	3	4	HNA 5	6
GROUP												
S												
MEAN	1143	1247	1273	1389	1159	1264	1359	1365	1126	1271	1350	1381
SD	284	271	320	349	342	253	290	360	336	329	364	378
Y												
MEAN	1001	1188	1410	1497	1021	1161	1387	1633	1009	1244	1425	1642
SD	149	275	347	413	138	180	297	452	171	238	350	477
E												
MEAN	1018	1192	1455	1599	1054	1261	1406	1594	1112	1315	1447	1639
SD	179	249	309	361	236	301	319	338	228	336	311	415
	SECOND SESSION											
	3	4	H 5	6	3	4	HA 5	6	3	4	HNA 5	6
S												
MEAN	980	1220	1314	1288	1048	1184	1235	1283	1081	1231	1276	1349
SD	199	222	272	214	195	265	214	239	283	263	253	257
Y												
MEAN	1040	1199	1335	1436	1037	1161	1309	1525	1017	1206	1358	1436
SD	295	328	317	360	230	264	304	479	245	345	400	449
E												
MEAN	1030	1219	1414	1519	1065	1189	1440	1509	1065	1309	1371	1561
SD	206	254	362	338	202	209	357	337	225	304	332	419
S=Schizophrenics Y=Young controls E=Elderly controls												

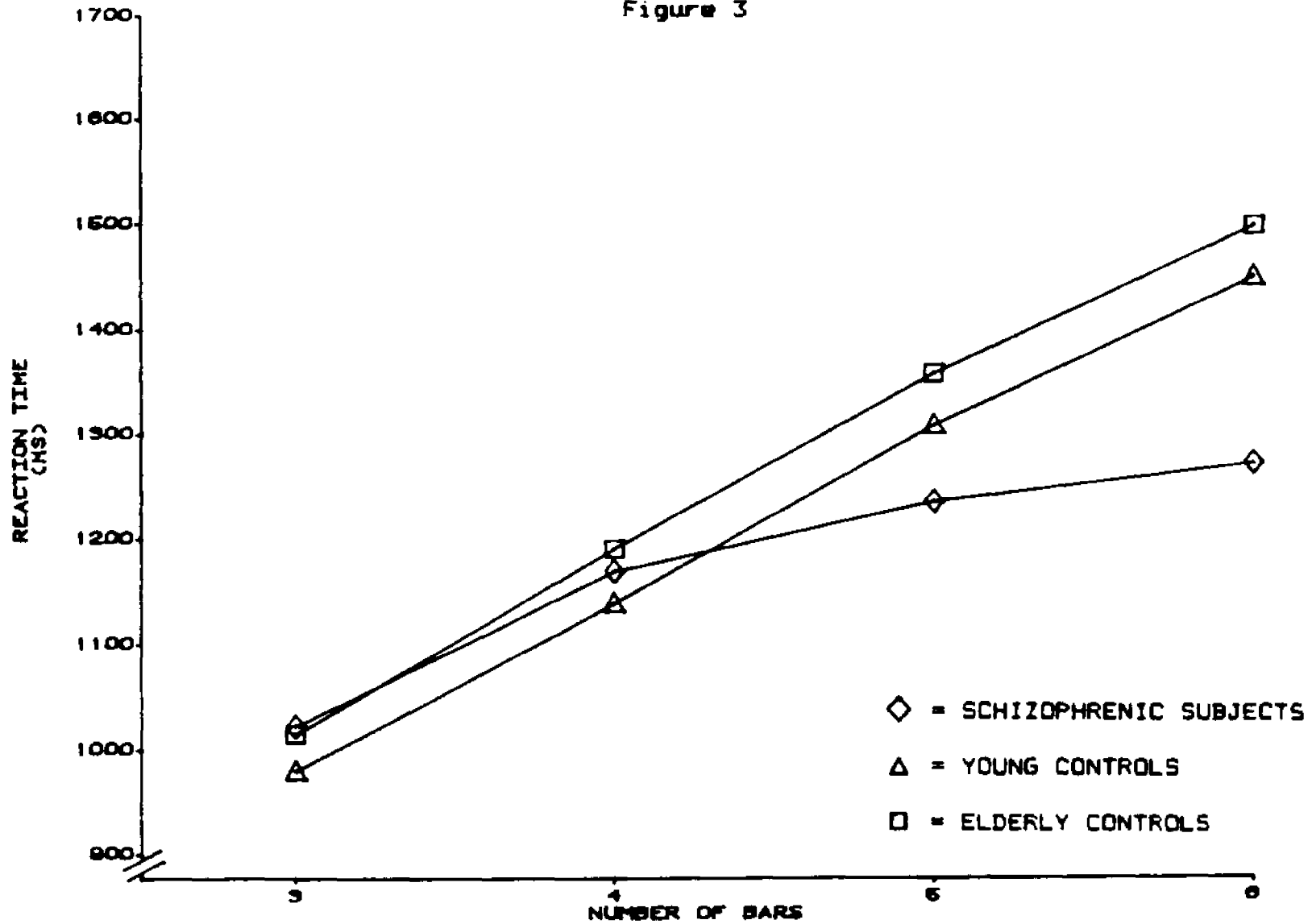
A priori contrasts indicated that the schizophrenic subjects were significantly faster than the young and elderly control subjects for five bars ($F(1,69) = 9.28686, p < .01$) and six bars ($F(1,69) = 34.4983, p < .01$), but no group differences for three or four bars. Reaction times did not differ significantly for the young and elderly controls. Figure 3 illustrates this group by number of bars interaction.

The a priori analysis of the group by number of bars interaction also revealed that as the number of bars presented increased the rate of increase (slope) of the reaction time function was significantly less for the schizophrenic group as compared with the two normal control groups, ($F(1,69) = 28.5161, p < .01$). A Scheffe analysis revealed a significant increase in reaction time with an increase in the number of bars presented for the control subjects but not for the schizophrenic subjects. Both groups of control subjects significantly increased in their reaction times as the number of bars increased from three to six (three bars significantly faster than four bars for the young controls, ($F(6,69) = 4.546, p < .01$) and the elderly controls, ($F(6,69) = 5.133, p < .01$); four bars significantly faster than five bars for the young controls, ($F(6,69) = 3.826, p < .01$) and the elderly controls, ($F(6,69) = 3.465, p < .01$); five bars significantly faster than six bars for young controls,

Figure Caption

Figure 3. Group by number of bars interaction for reaction times of the combined first and second sessions. (◇) represents schizophrenic subjects, (▲) represents young control subjects, and (□) represents elderly control subjects.

Figure 3



($F(6,69) = 2.086, p < .10$) and elderly controls, ($F(6,69) = 1.893, p < .10$). The schizophrenic subjects in comparison significantly increased in reaction time from the three to four bar display, ($F(6,69) = 3.587, p < .01$) but were not significantly slower as the number of bars presented increased from four to six.

The condition by session interaction showed that only reaction times for the two heterogeneous conditions were significantly faster in the second session ($p < .01$).

The number of bars by session interaction indicated that reaction time was significantly faster only for six bars in the second session ($p < .05$).

A post hoc analysis of the number of bars by condition interaction revealed significant increases in reaction time as the number of bars increased from three to four in the Homogeneous condition, ($F(6,138) = 12.5477$), $p < .01$; Heterogeneous/Adjacent condition, ($F(6,138) = 7.9303$), $p < .01$; and the Heterogeneous/Nonadjacent condition, ($F(6,138) = 13.9546$), $p < .01$. Significant increases in reaction time also occurred as the number of bars increased from four to five in the Homogeneous condition, ($F(6,138) = 7.6098$), $p < .01$; the Heterogeneous/Adjacent condition, ($F(6,138) = 7.495$), $p < .01$; and the Heterogeneous/Nonadjacent condition, ($F(6,138) = 3.479$), $p < .01$. Significant increases in reaction time from five

to six bar displays only occurred in the Heterogeneous/Adjacent condition, ($F(6,138) = 3.363$), $p < .01$; and the Heterogeneous/Nonadjacent condition, ($F(6,138) = 3.9417$), $p < .01$. There was no significant increase in reaction time associated with an increase of from five to six bars in the Homogeneous condition.


The four-way interaction (group x block x number of bars x condition) is depicted in Figures 4a, 4b, 4c, and 4d. This significant interaction seems to indicate that schizophrenic subjects were significantly faster than control subjects in early blocks of trials when six bars were presented but differences among the perceptual grouping conditions became most apparent at six bars for control subjects, as compared with schizophrenic subjects on the last block of trials.


Additional Analyses


Groups with comparable accuracy - first session. The primary reason for employing a threshold procedure was to be able to determine whether reaction time differences existed among the groups when accuracy of the groups was comparable. However, for several patients the threshold procedure did not insure that the subjects had comparable accuracy thus, it was not possible to use the entire group for this analysis since some schizophrenic subjects performed at accuracy levels below chance (17%, 20%, &

Figure Caption

Figure 4a. Group by condition by number of bars interaction for reaction times of the combined first and second sessions - First block of trials (B1).

Solid lines with a cross at each of the data points represent the Homogeneous condition ().

Broken lines with an x at each of the data points represent the Heterogeneous/Adjacent condition ().

Dotted and broken lines with a dot at each of the data points represent the Heterogeneous/Nonadjacent condition ().

S = schizophrenic subjects

YN = young normal subjects

EN = elderly normal subjects

Figure 4a.

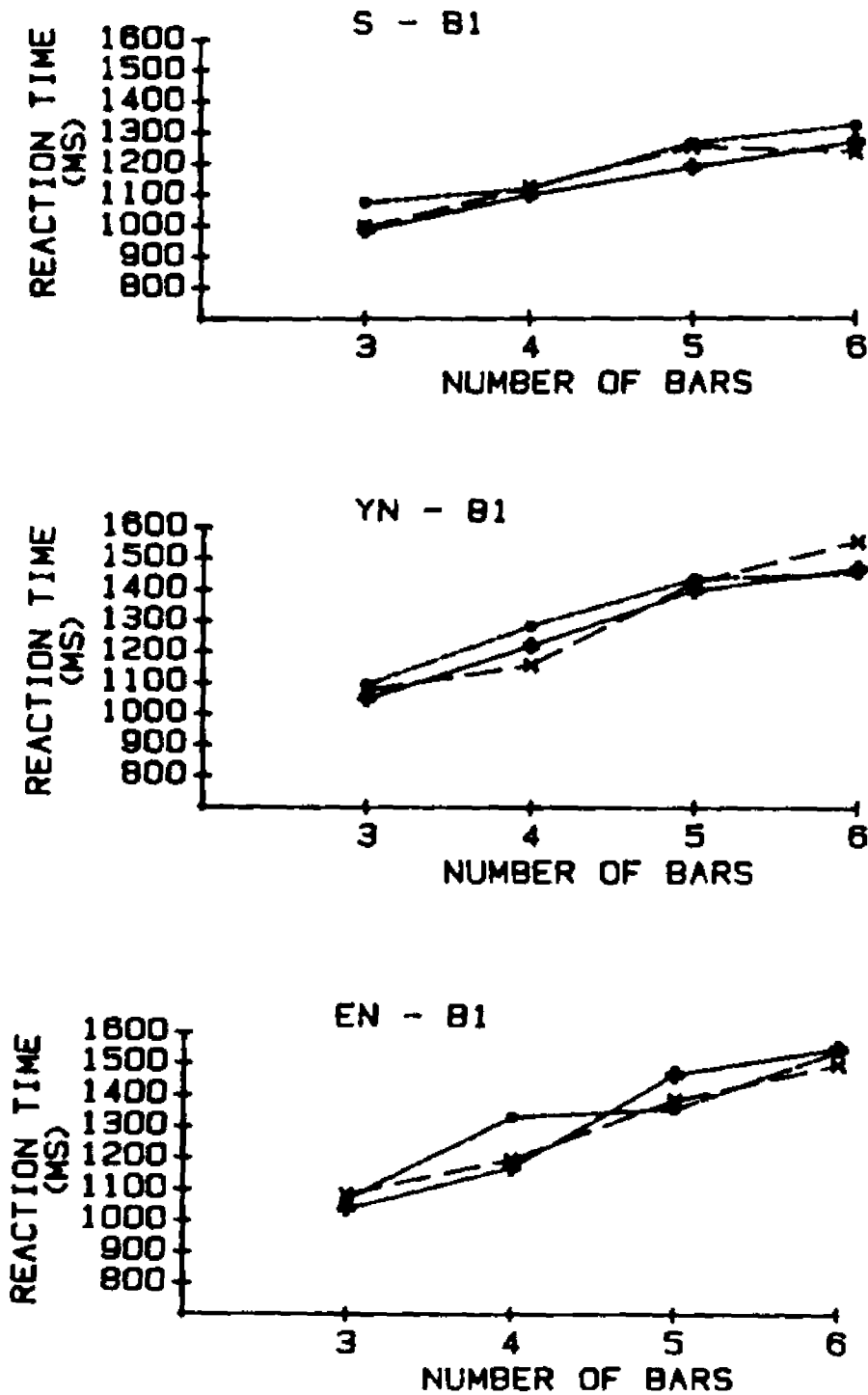


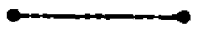


Figure Caption

Figure 4b. Group by condition by number of bars interaction for reaction times of the combined first and second sessions - Second block of trials (B2). Solid lines with a cross at each of the data points represent the Homogeneous condition (). Broken lines with an x at each of the data points represent the Heterogeneous/Adjacent condition (). Dotted and broken lines with a dot at each of the data points represent the Heterogeneous/Nonadjacent condition ().

S = schizophrenic subjects
 YN = young normal subjects
 EN = elderly normal subjects

Figure 4b.

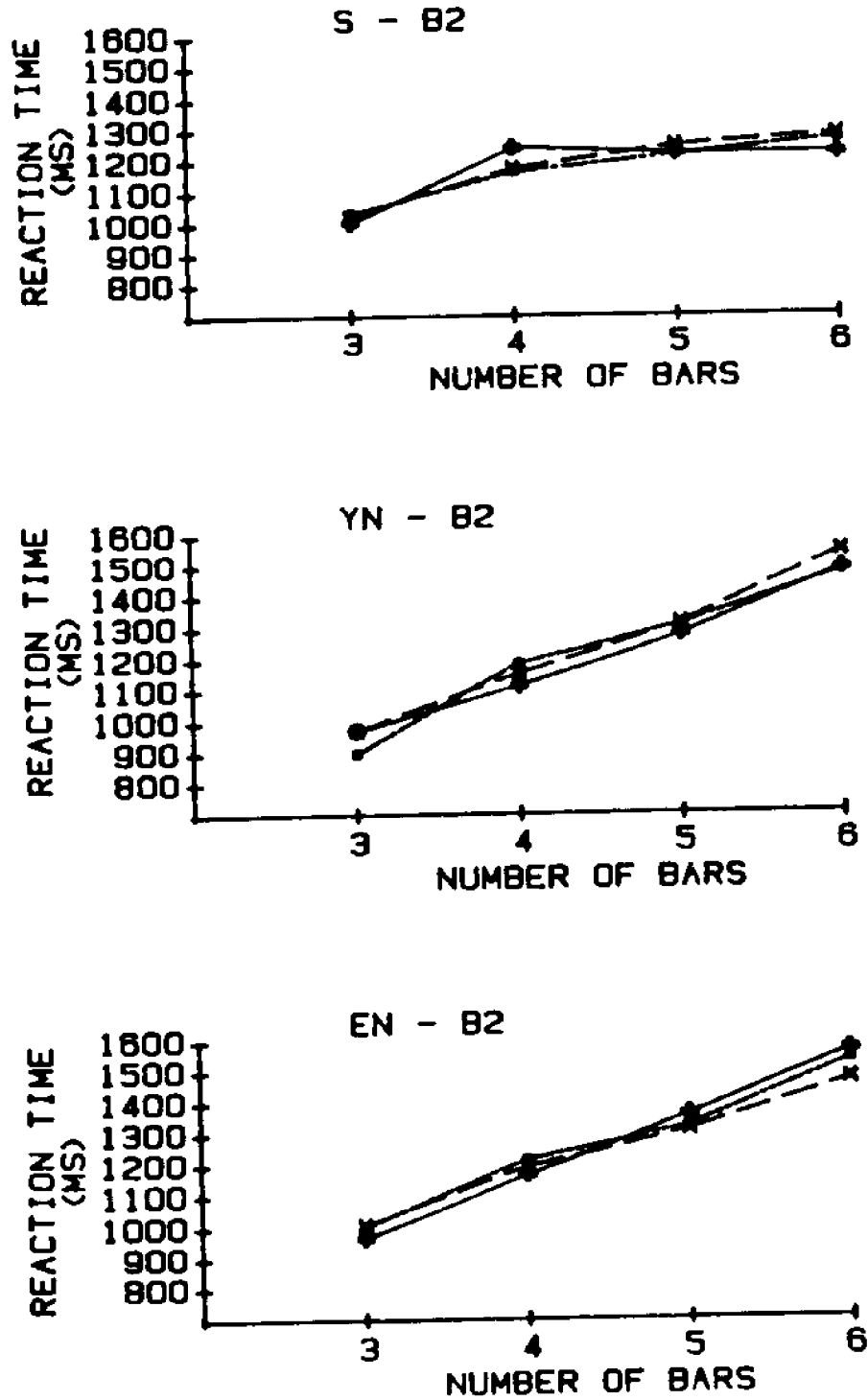





Figure Caption

Figure 4c. Group by condition by number of bars interaction for reaction times of the combined first and second sessions - Third block of trials (B3).

Solid lines with a cross at each of the data points represent the Homogeneous condition ().

Broken lines with an x at each of the data points represent the Heterogeneous/Adjacent condition ().

Dotted and broken lines with a dot at each of the data points represent the Heterogeneous/Nonadjacent condition ().

S = schizophrenic subjects

YN = young normal subjects

EN = elderly normal subjects

Figure 4c.

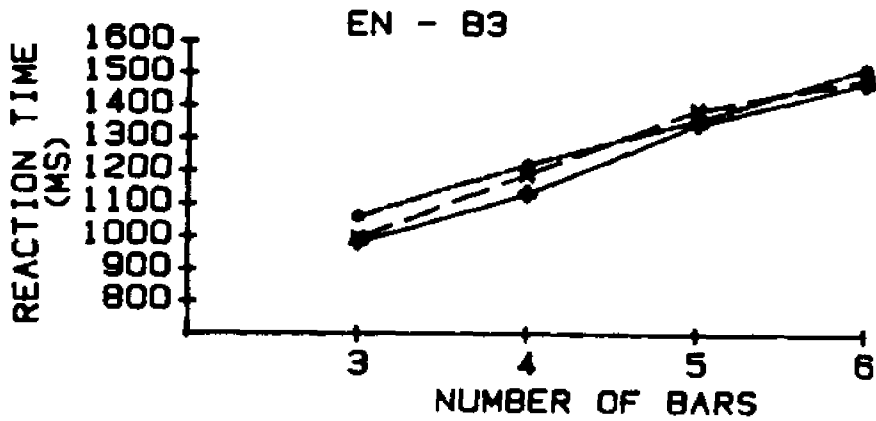
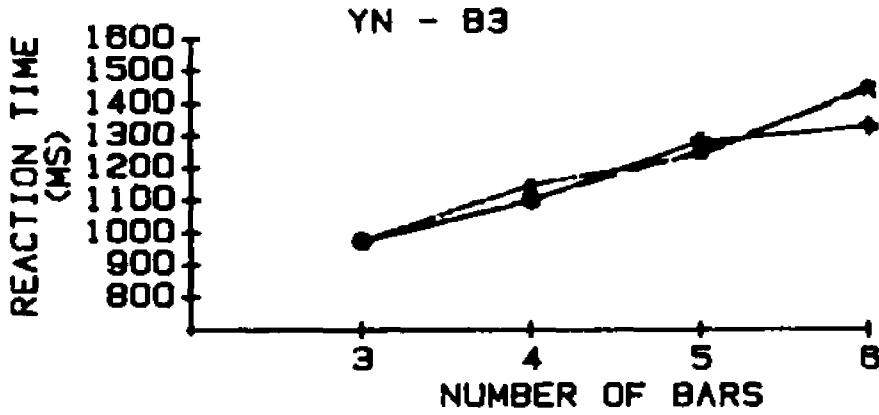
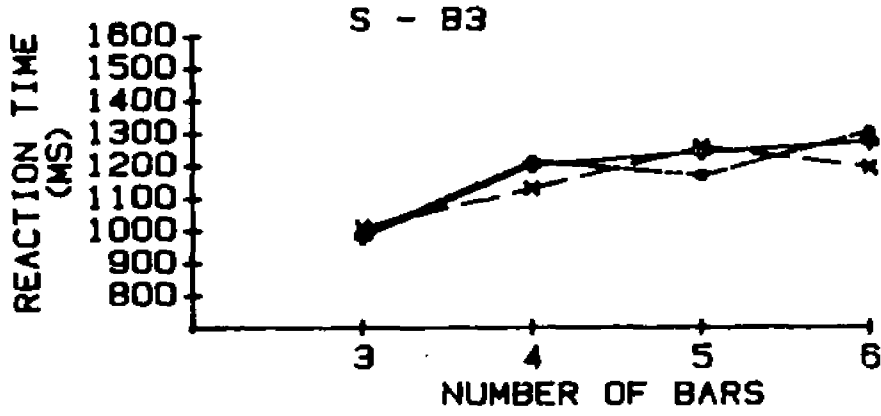




Figure Caption

Figure 4d. Group by condition by number of bars interaction for reaction times of the combined first and second sessions - Fourth block of trials (B4).

Solid lines with a cross at each of the data points represent the Homogeneous condition ().

Broken lines with an x at each of the data points represent the Heterogeneous/Adjacent condition

().

Dotted and broken lines with a dot at each of the data points represent the Heterogeneous/Nonadjacent condition

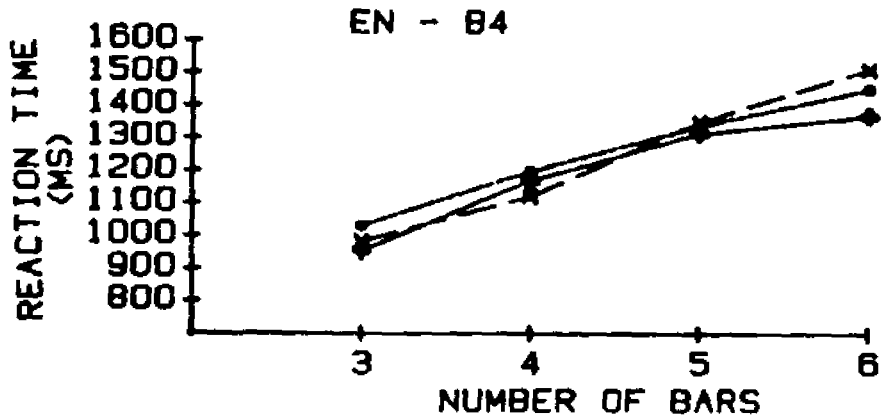
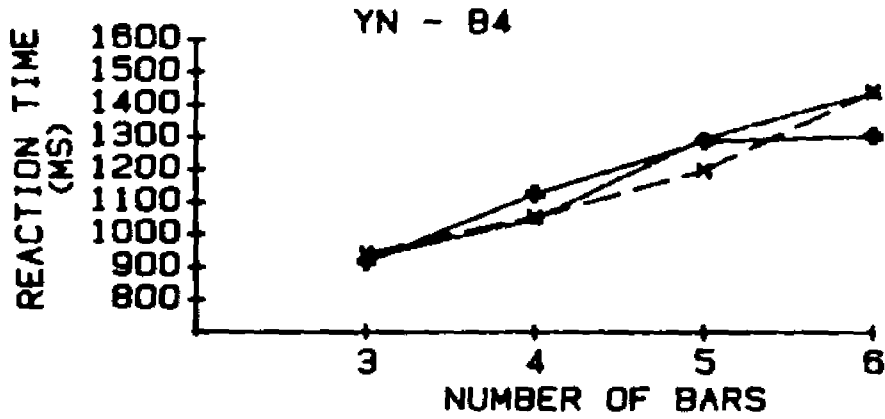
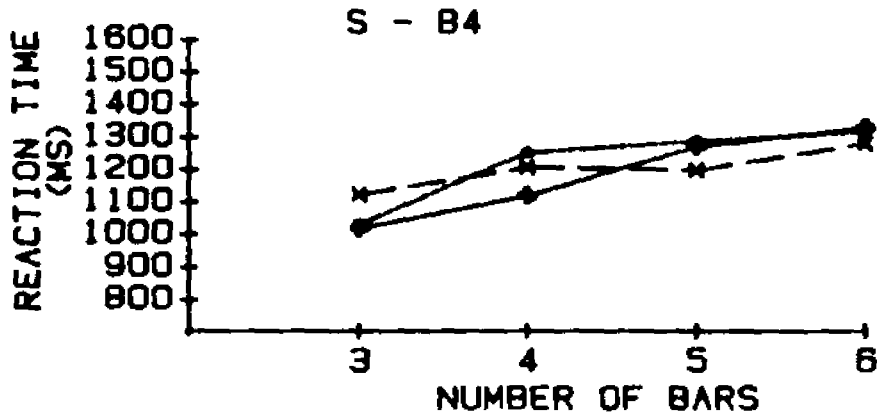
().

S = schizophrenic subjects

YN = young normal subjects

EN = elderly normal subjects

Figure 4d.



23%). Also, two young normals and two older normals displayed very high levels of accuracy (96%, 95%, 92%, & 85%, respectively). When these extreme scores were eliminated from the analysis, the group differences in accuracy were no longer statistically significant in a one-way ANOVA.

In order to determine whether the reaction times among the three groups differed when the groups had comparable accuracy scores, the three groups of subjects who did not demonstrate significant accuracy differences were compared (seven schizophrenic subjects, eight young normals and eight elderly) in a four-way ANOVA (group x block x condition x number of bars).

Mean proportion correct and mean reaction times are presented in Table 10. Inspection of the table show schizophrenic subjects to have faster reaction times than controls as the number of bars increase. In addition, schizophrenic subjects also show more similar reaction times for the three perceptual organizational conditions than both young and elderly controls. Significant main effects were obtained for number of bars, ($p < .0001$) and conditions, ($p < .01$). An additional group by number of bars interaction ($p < .02$) was again obtained, indicating significantly faster reaction times for schizophrenic subjects than normal controls with increases in the number of bars, collapsed across the organizational

Table 10

Mean proportion correct and mean reaction times (ms) for the different conditions and different number of bars presented for groups with comparable accuracy (first session).

	MEAN PROPORTION CORRECT											
	H				HA				HNA			
	3	4	5	6	3	4	5	6	3	4	5	6
GROUP												
S												
MEAN	.72	.51	.65	.49	.66	.52	.55	.43	.63	.57	.57	.36
SD	.27	.19	.16	.27	.24	.26	.20	.33	.26	.26	.28	.24
Y												
MEAN	.74	.74	.70	.70	.75	.68	.73	.63	.82	.59	.70	.59
SD	.18	.22	.15	.21	.18	.09	.12	.15	.22	.18	.15	.17
E												
MEAN	.79	.85	.67	.62	.75	.70	.61	.59	.75	.62	.69	.49
SD	.17	.14	.13	.19	.16	.21	.21	.25	.10	.18	.19	.22

	MEAN REACTION TIME (MS)											
	H				HA				HNA			
	3	4	5	6	3	4	5	6	3	4	5	6
S												
MEAN	1112	1208	1279	1309	1065	1199	1322	1355	1091	1285	1329	1332
SD	284	231	299	306	263	231	262	360	325	327	301	340
Y												
MEAN	981	1177	1360	1477	999	1158	1336	1560	974	1214	1381	1596
SD	167	310	403	470	160	196	346	499	205	289	381	521
E												
MEAN	1022	1181	1481	1653	1086	1249	1430	1626	1108	1322	1517	1696
SD	168	244	324	285	228	225	325	326	205	280	333	419

S=Schizophrenics Y=Young controls E=Elderly controls

conditions. The analysis of variance is summarized in Appendix E. Post hoc tests indicated that reaction time increased significantly ($p < .05$) as the number of bars increased, again demonstrating the perceptual span effect. Reaction time was found to increase significantly ($p < .05$) from the Homogeneous condition to the Heterogeneous/Nonadjacent condition. An a priori contrast revealed significantly faster reaction times for schizophrenic subjects as compared to control subjects (both the young and elderly) for five bar ($F(1,60) = 4.16584, p < .05$) and six bar ($F(1,60) = 23.9263, p < .01$) displays. The rate of increase in reaction times with increases in the number of bars presented was significantly less for the schizophrenic subjects than both groups of control subjects ($F(1,60) = 17.8108, p < .01$). Figure 5 illustrates the group by number of bars interaction.

In addition, the young control subjects were significantly faster than the elderly subjects for five bar displays ($F(1,60) = 4.3793, p < .05$).

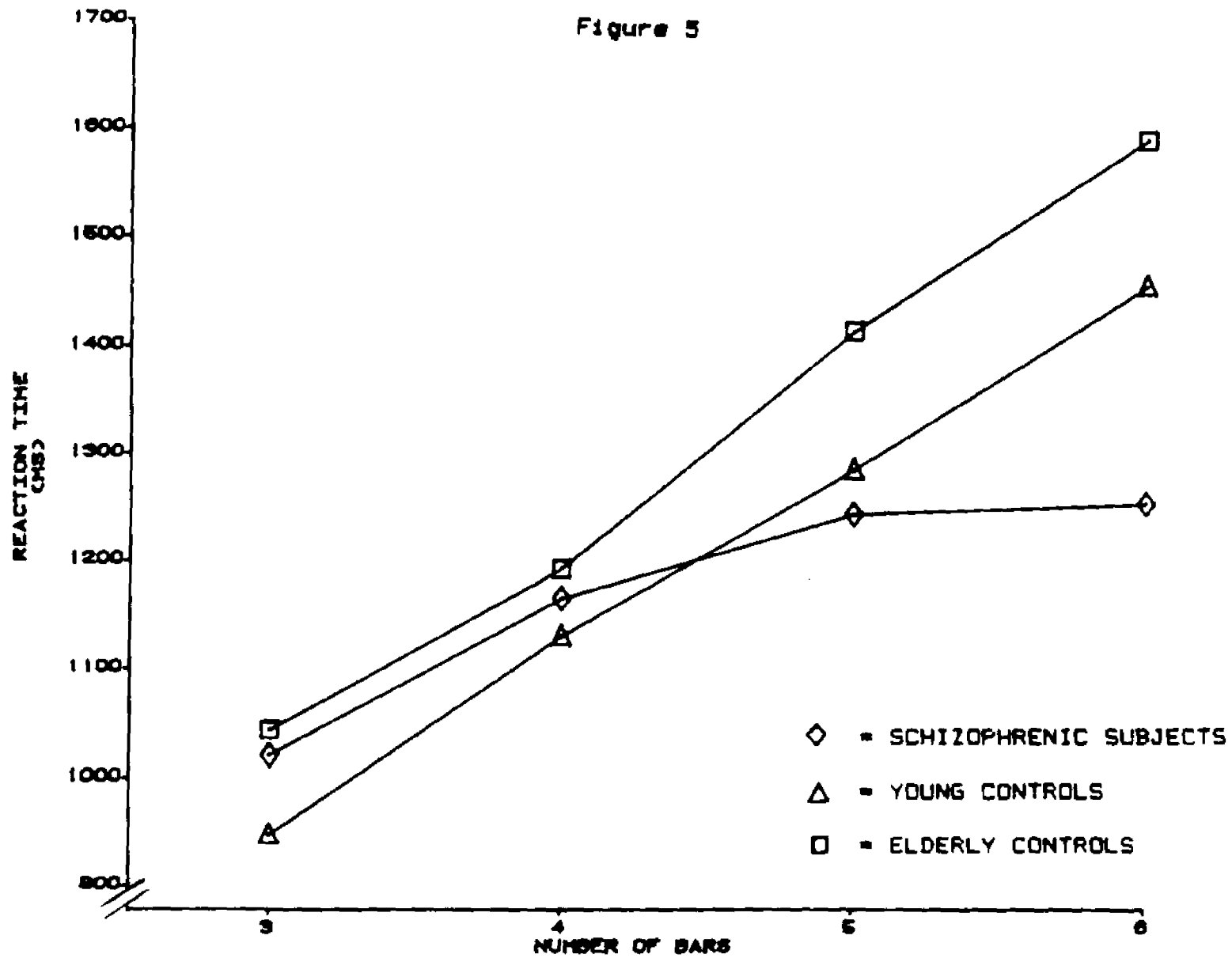
Groups with comparable accuracy - second session.

The same subjects with comparable accuracy in the first session were compared again in an analysis of the second session. A loss of subjects due to their unavailability for testing resulted in groups consisting of five schizophrenic, seven young control, and seven elderly

Figure Caption

Figure 5. Group by number of bars interaction for reaction times of seven schizophrenic, eight young normal control, and eight elderly normal control subjects with comparable accuracy in the first session.

(◇) represents schizophrenic subjects, (Δ) represents young control subjects, and (□) represents elderly control subjects.



control subjects in the second testing. Comparable accuracy levels were obtained in a one-way ANOVA. Mean proportion correct and mean reaction times are presented in Table 11.

A four-way analysis of variance (group x block x condition x number of bars) for the reaction times of the selected subjects revealed a significant main effect of blocks, ($p < .03$), and number of bars, ($p < .0001$). An additional significant four-way interaction (group x block x number of bars x condition) was also obtained ($p < .05$). The conditions were no longer significantly different in the second session. The analysis of variance is summarized in Appendix F.

The four-way interaction (group x block x number of bars x condition) depicted in Figures 6a, 6b, 6c, and 6d shows a decrease in reaction times at six bars for the heterogeneous conditions in the last block of trials, particularly for the normal subjects.

Reaction times of only correct answers. An additional analysis was performed on reaction times associated only with correct answers. Subjects for this analysis were selected if they had a minimum of three correct answers at every bar number in each condition.

The median reaction times for four schizophrenic, ten young normals and eight normal elderly subjects were compared in a three-way analysis of variance (group x

Table 11




Mean proportion correct and mean reaction time scores for the three groups of subjects with comparable accuracy (second session) for the different conditions and different number of bars presented.

GROUP	MEAN PROPORTION CORRECT											
	H				HA				HNA			
	3	4	5	6	3	4	5	6	3	4	5	6
S												
MEAN	.78	.64	.63	.48	.73	.68	.65	.40	.70	.48	.57	.30
SD	.25	.30	.27	.31	.32	.22	.23	.26	.36	.31	.34	.22
Y												
MEAN	.80	.66	.56	.58	.82	.75	.68	.57	.63	.68	.68	.45
SD	.20	.13	.13	.05	.10	.11	.13	.15	.22	.13	.15	.19
E												
MEAN	.77	.76	.67	.60	.81	.70	.57	.59	.73	.68	.61	.48
SD	.19	.20	.20	.29	.13	.23	.22	.28	.23	.24	.19	.27

GROUP	MEAN REACTION TIME (MS)											
	H				HA				HNA			
	3	4	5	6	3	4	5	6	3	4	5	6
S												
MEAN	996	1195	1267	1278	1040	1131	1181	1322	1042	1184	1253	1409
SD	206	237	310	223	209	249	239	235	245	269	249	268
Y												
MEAN	976	1154	1293	1399	989	1120	1254	1476	948	1151	1334	1389
SD	269	342	335	352	202	244	312	480	188	370	447	474
E												
MEAN	1033	1211	1421	1573	1037	1195	1460	1522	1068	1290	1342	1608
SD	214	238	364	333	185	193	351	319	244	280	243	408

S=Schizophrenics Y=Young controls E=Elderly controls

Figure Caption

Figure 6a. Group by condition by number of bars interaction in the second session for five schizophrenic, seven young controls, and seven elderly controls with comparable accuracy - First block of trials (B1). Solid lines with a cross at each of the data points represent the Homogeneous condition (). Broken lines with an x at each of the data points represent the Heterogeneous/Adjacent condition (). Dotted and broken lines with a dot at each of the data points represent the Heterogeneous/Nonadjacent condition ().

S = schizophrenic subjects
 YN = young normal subjects
 EN = elderly normal subjects

Figure 6a.

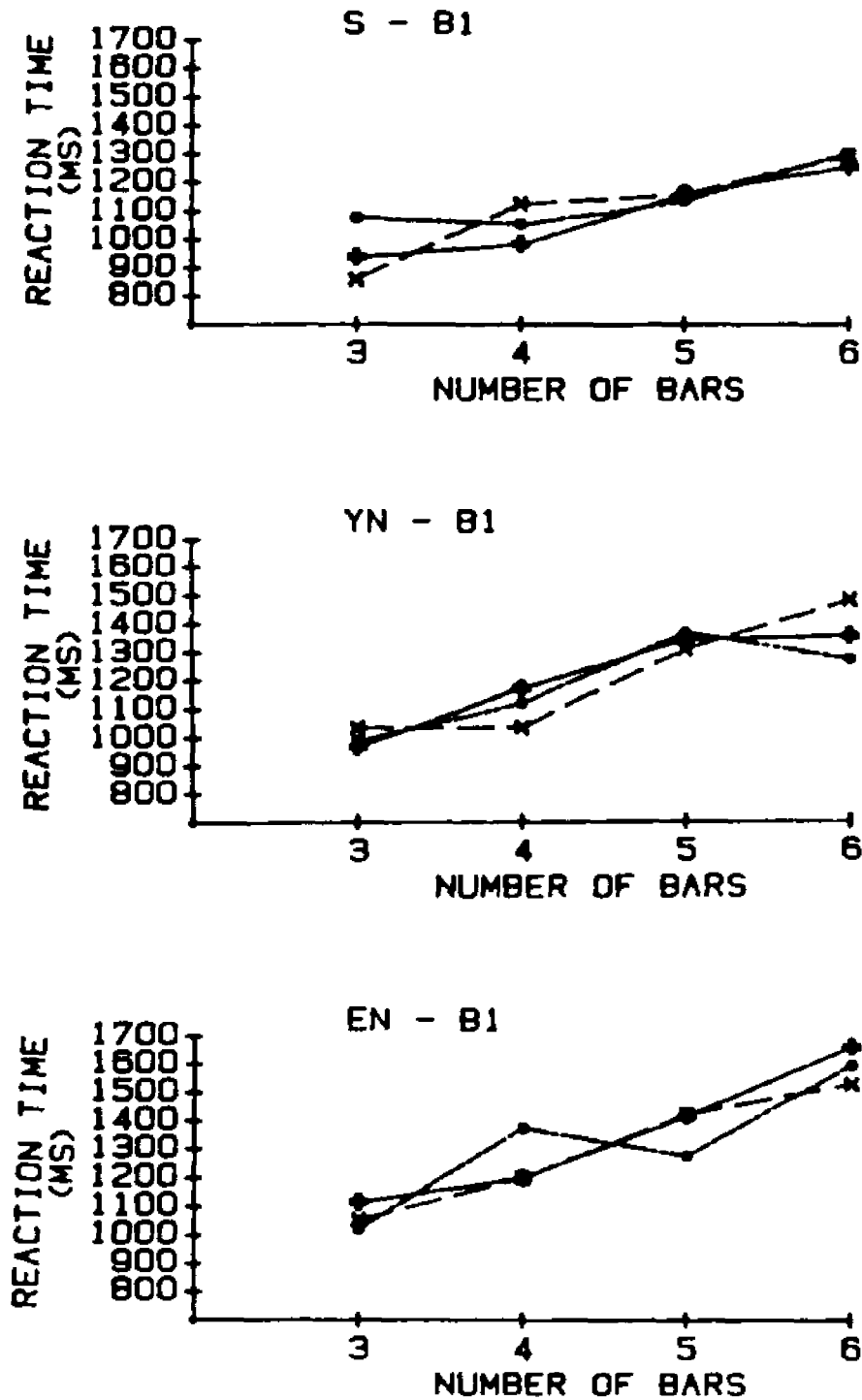


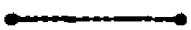


Figure Caption

Figure 6b. Group by condition by number of bars interaction in the second session for five schizophrenic, seven young controls, and seven elderly controls with comparable accuracy - Second block of trials (B2).

Solid lines with a cross at each of the data points represent the Homogeneous condition ().

Broken lines with an x at each of the data points represent the Heterogeneous/Adjacent condition ().

Dotted and broken lines with a dot at each of the data points represent the Heterogeneous/Nonadjacent condition ().

S = schizophrenic subjects

YN = young normal subjects

EN = elderly normal subjects

Figure 6b.

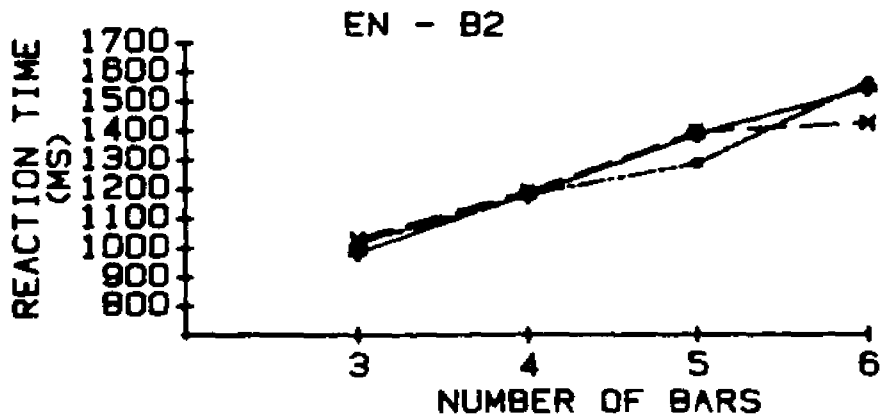
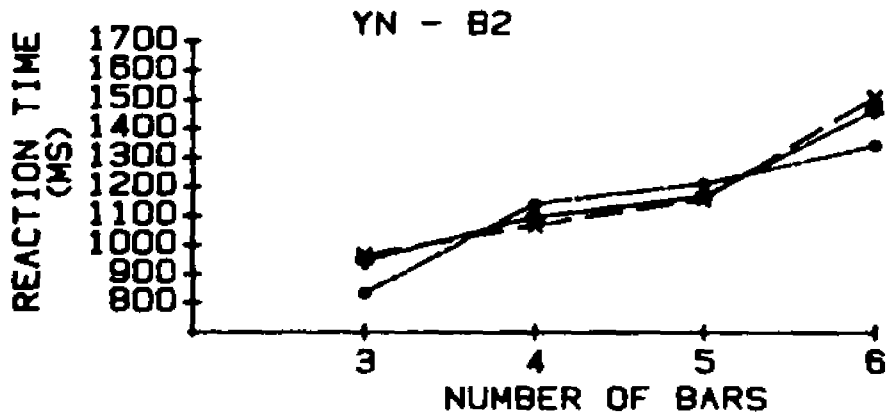
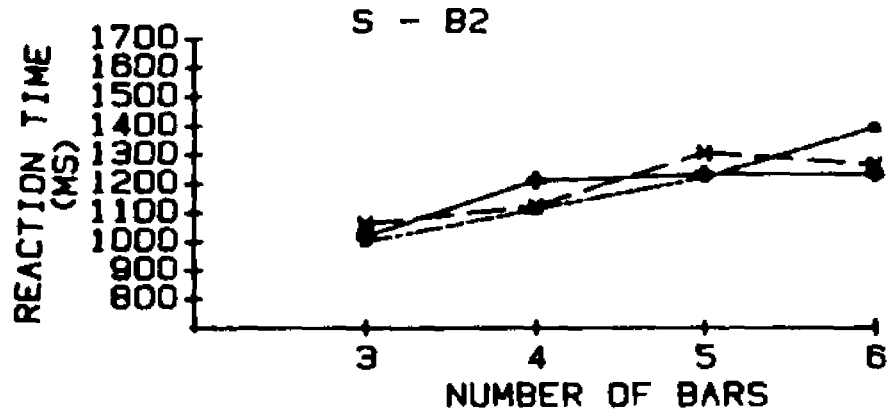

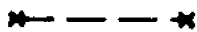



Figure Caption

Figure 6c. Group by condition by number of bars interaction in the second session for five schizophrenic, seven young controls, and seven elderly controls with comparable accuracy - Third block of trials (B3).

Solid lines with a cross at each of the data points represent the Homogeneous condition ().

Broken lines with an x at each of the data points represent the Heterogeneous/Adjacent condition ().

Dotted and broken lines with a dot at each of the data points represent the Heterogeneous/Nonadjacent condition ().

S = schizophrenic subjects

YN = young normal subjects

EN = elderly normal subjects

Figure 6c.

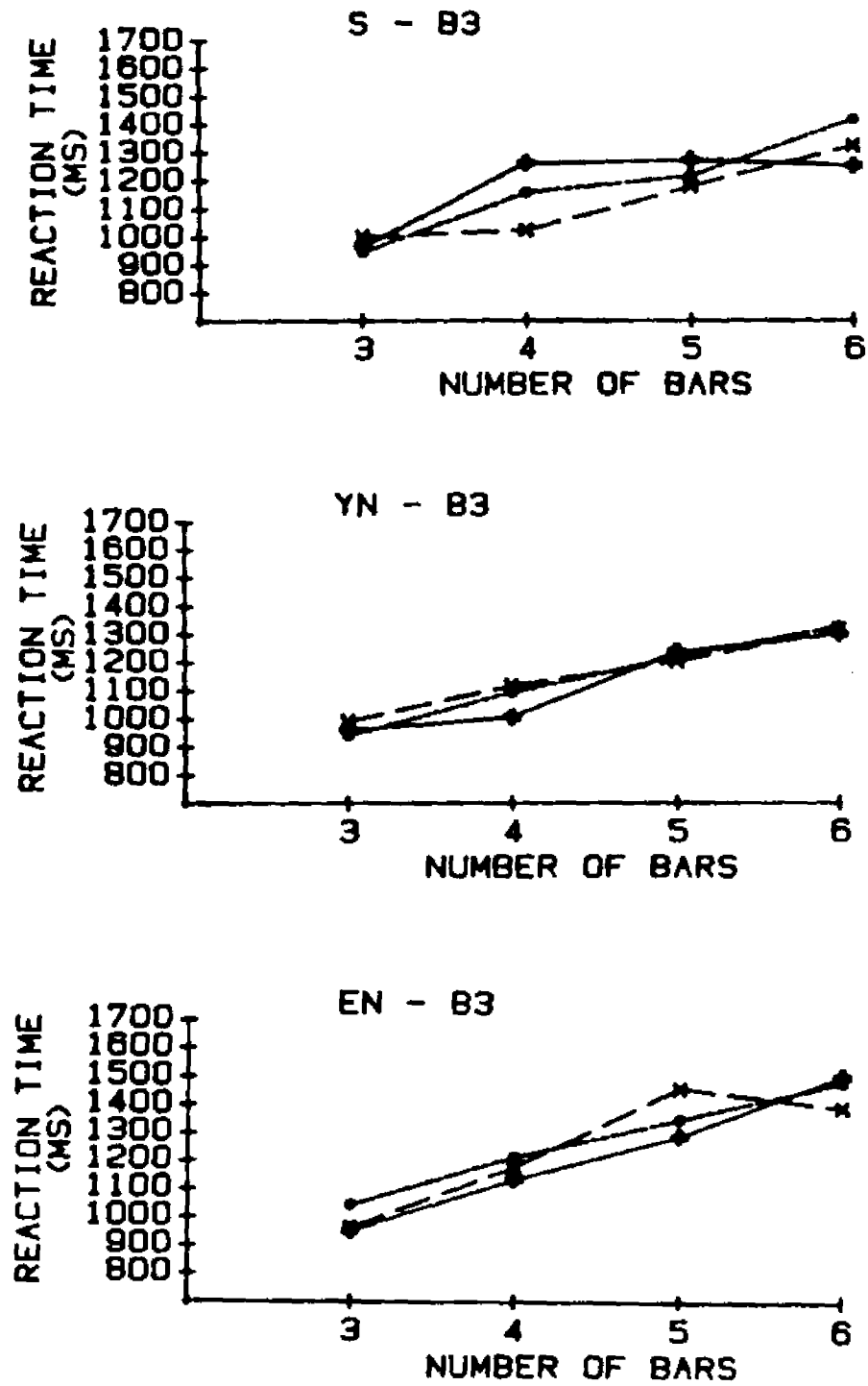



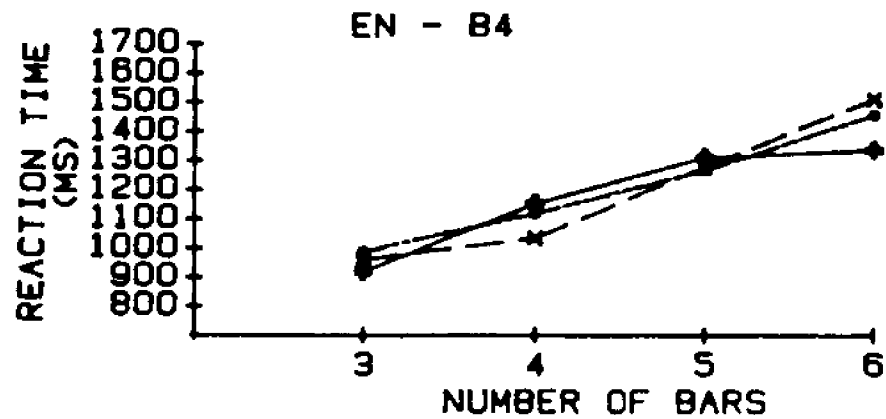
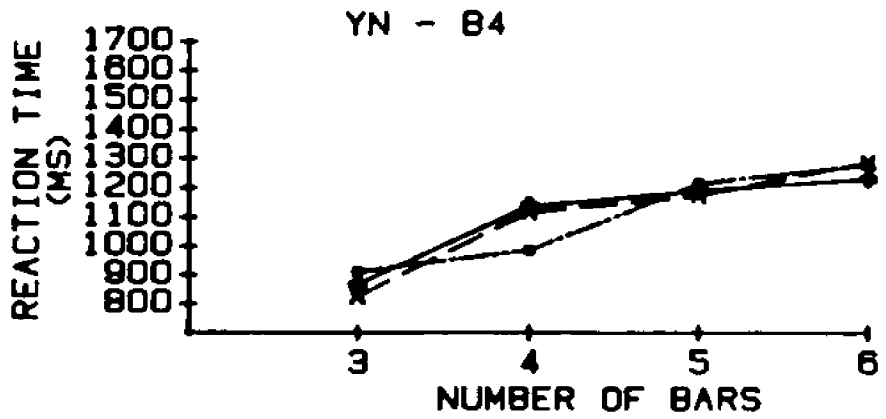
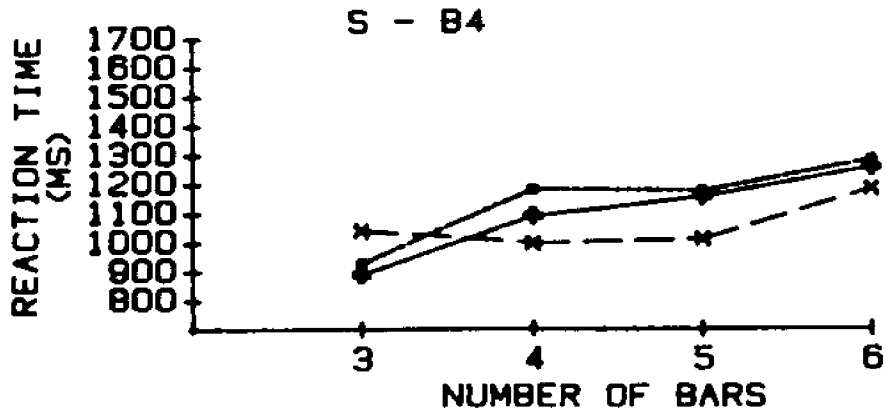


Figure Caption

Figure 6d. Group by condition by number of bars interaction in the second session for five schizophrenic, seven young controls, and seven elderly controls with comparable accuracy - Fourth block of trials (B4). Solid lines with a cross at each of the data points represent the Homogeneous condition (). Broken lines with an x at each of the data points represent the Heterogeneous/Adjacent condition (). Dotted and broken lines with a dot at each of the data points represent the Heterogeneous/Nonadjacent condition ().

S = schizophrenic subjects
 YN = young normal subjects
 EN = elderly normal subjects

Figure 6d.



condition x number of bars). Significant main effects of number of bars, ($p < .0001$); and condition ($p < .02$) were obtained. The group by number of bars interaction did not quite reach statistical significance when an epsilon correction was used ($p = .07$) but did reach significance without this correction ($p = .05$).

The a priori assumption that the schizophrenic subjects would respond faster than control subjects as the number of bars increased when collapsed across conditions does seem apparent from the plot of the medians in Figure 7. Because of the large differences in the number of subjects in each group a post hoc analysis was not employed. The median reaction times are presented in Table 12. The analysis of variance is summarized in Appendix G.

Number of bars reported. The number of bars reported are presented in Table 13. The schizophrenic subjects reported more bars in each of the three conditions than control subjects. An analysis of variance was performed in order to determine whether differences existed among the groups (eight schizophrenic subjects, nine young normal, and nine elderly normal subjects) in the number of bars reported under each of the organizational conditions.

In a four-way ANOVA (session x group x condition x number of bars), it was determined that there was a main

Figure Caption

Figure 7. Group by number of bars interaction for reaction times of only correct answers. (◇) represents schizophrenic subjects, (Δ) represents young control subjects, and (□) represents elderly control subjects.

Figure 7

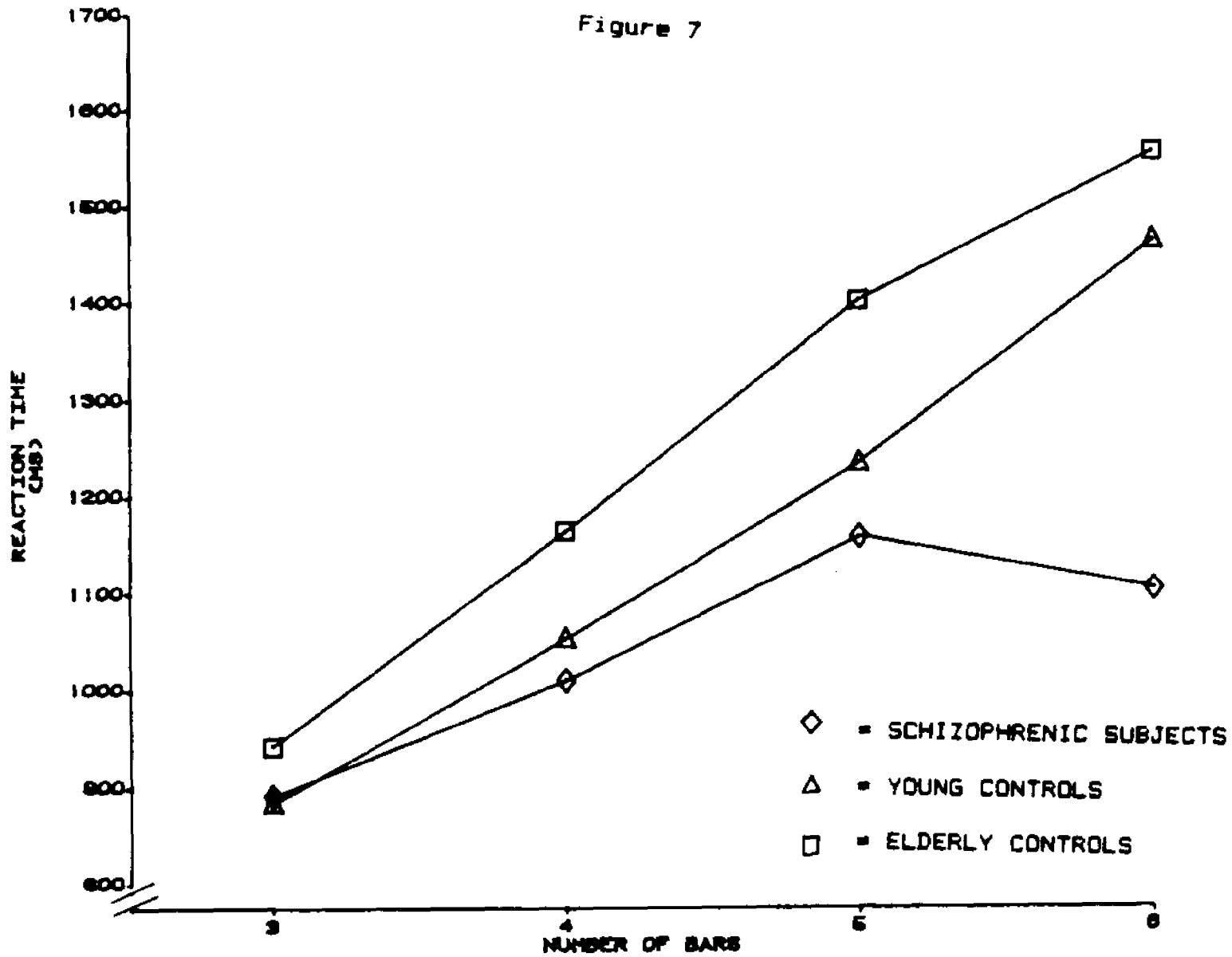


Table 12

Median reaction times (ms) for only correct answers. The scores are for three conditions of perceptual organization and four different number of bars for the three groups of subjects.

	3	4	H 5	6	3	4	HA 5	6	3	4	HNA 5	6
<hr/>												
GROUP												
S												
MEAN	924	974	1229	1076	884	1016	1097	1113	905	1088	1178	1148
SD	182	183	190	105	170	193	135	186	156	213	166	209
Y												
MEAN	867	1055	1274	1408	918	1021	1256	1556	890	1117	1284	1607
SD	111	153	359	382	116	103	287	476	153	218	342	563
E												
MEAN	934	1114	1443	1554	980	1188	1412	1603	967	1302	1474	1652
SD	187	255	345	382	201	267	311	391	235	425	408	478

S=Schizophrenics Y=Young controls E=Elderly controls

Table 13

Mean number of bars reported by the three groups of subjects for the different conditions and different number of bars presented.

		FIRST SESSION											
		H				HA				HNA			
		3	4	5	6	3	4	5	6	3	4	5	6
GROUP													
S	MEAN	3.11	4.00	4.93	5.96	3.05	4.30	5.01	5.83	3.07	4.21	5.22	6.21
	SD	.77	.92	1.03	1.28	.48	.93	1.18	1.59	.64	.70	1.63	1.50
Y	MEAN	3.08	4.06	5.06	5.91	3.06	4.06	4.99	5.95	3.03	4.15	4.99	6.07
	SD	.19	.18	.31	.36	.26	.23	.36	.25	.21	.36	.31	.50
E	MEAN	2.93	3.95	4.88	6.02	2.98	3.97	4.75	5.70	3.06	3.94	4.80	5.72
	SD	.25	.19	.23	.48	.26	.26	.39	.54	.22	.40	.33	.66
		SECOND SESSION											
		H				HA				HNA			
		3	4	5	6	3	4	5	6	3	4	5	6
S	MEAN	3.00	4.14	5.16	6.17	3.09	4.15	4.99	6.03	3.11	4.15	5.11	6.33
	SD	.53	.77	.84	1.04	.66	.54	.98	1.22	.84	.65	1.12	1.19
Y	MEAN	2.99	3.79	4.59	5.88	2.91	3.71	4.74	5.83	2.84	3.73	4.70	5.43
	SD	.20	.34	.53	.42	.23	.35	.35	.52	.44	.40	.51	.84
E	MEAN	2.84	3.82	4.78	5.78	2.99	3.85	4.84	5.72	2.83	3.75	4.66	5.61
	SD	.21	.42	.63	.68	.16	.47	.56	.89	.42	.45	.59	.96
S=Schizophrenics		Y=Young controls				E=Elderly controls							

effect of number of bars, ($p < .0001$) and two significant interactions: A session by condition interaction ($p < .05$) and a group by condition interaction ($p = .05$). The analysis of variance is summarized in Appendix H.

The main effect of number of bars demonstrated that the reported number of bars increase as the number of bars presented increase. A Scheffe analysis revealed that significantly fewer bars were reported in the second session for the Homogeneous condition ($F(2,46) = 2.770$, $p < .10$) and the Heterogeneous/Nonadjacent condition ($F(2,46) = 15.3184$, $p < .01$).

A post hoc analysis of the group by condition interaction indicated that the schizophrenic subjects reported significantly more bars in each condition than the control subjects: the Homogeneous condition ($F(4,46) = 3.8126$, $p < .05$); the Heterogeneous/Adjacent condition ($F(4,46) = 4.7461$, $p < .01$); and the Heterogeneous/Nonadjacent condition ($F(4,46) = 17.6547$, $p < .01$).

The mean number of bars reported by the schizophrenic subjects was the same for both the Homogeneous and Heterogeneous/Adjacent conditions, while an increased number of bars were reported in the Heterogeneous/Nonadjacent condition. The slope of this function for the schizophrenic subjects was significantly different from that of both normal controls ($F(4,46) =$

2.5294, $p < .10$) who in comparison, decreased in the number of bars reported from the Homogeneous to the Heterogeneous/Adjacent to the Heterogeneous/Nonadjacent condition.

Correlations between accuracy and reaction time - combined first and second sessions. Significant negative correlations (longer reaction times associated with less accuracy and faster reaction times associated with more accuracy) were found for schizophrenic subjects for three bars in in the Homogeneous condition ($r = -.78$, $p < .05$), three and four bars in the Heterogeneous/Adjacent condition ($r = -.82$, $p < .05$ and $r = -.80$, $p < .05$ respectively), and three and four bars in the Heterogeneous/Nonadjacent conditions ($r = -.88$, $p < .05$ and $r = -.79$, $p < .05$ respectively). A significant negative correlation was also found for young normal subjects for four bars in the Homogeneous condition ($r = -.68$, $p < .05$). These results suggest that speed-accuracy trade-off differences did not occur among the three groups.

Correlations between accuracy and reaction time for subjects with comparable accuracy scores. Significant negative correlations were found for schizophrenic subjects for three, four, and five bars in the Homogeneous condition ($r = -.89$, $p < .05$; $r = -.87$, $p < .05$; and $r = -.83$, $p < .05$ respectively); three and four bars in the Heterogeneous/Adjacent condition ($r = -.92$, $p < .05$ and

$r = -.88$, $p < .05$ respectively); and for three bars in the Heterogeneous/Nonadjacent condition ($r = -.93$, $p < .05$). A significant negative correlation was also found for elderly normal subjects for three bars in the Heterogeneous/Adjacent condition, ($r = -.71$, $p = .05$). These correlations also suggest that speed-accuracy trade-off differences among groups did not occur.

Discussion

A major finding from this study is that schizophrenic patients showed faster reaction times than young and elderly control subjects across conditions when five and six bars were presented. Furthermore, schizophrenic subjects responded with faster reaction times regardless of whether all patients were compared with control subjects or only patients and controls with comparable accuracy scores were compared. In addition, the significant differences in filter density thresholds found among the three groups of subjects suggest that sensory differences existed prior to the main experiment. If, as Frith (1973) contends, all stimuli are necessarily organized, then more energy may be needed for schizophrenic and elderly control subjects to perceive organization in the environment than for young control subjects. Alternatively, the differences in filter density thresholds may indicate less effort on the part of the schizophrenic subjects and elderly control subjects. However, the findings of faster reaction times for schizophrenic patients under some conditions of the main experiment militates against the latter interpretation.

Tables 14a and 14b summarize the predicted outcomes and results of the present experiment. These tables

Table 14a.

Summary of predicted outcomes and actual results for accuracy in normal controls (C) and schizophrenic subjects (S) for the perceptual span, perceptual groupings, and good figure.

PERCEPTUAL SPAN (changes in accuracy resulting from an increase in the number of bars).

Predictions

C - Accuracy decreases with an increased number of bars.

S - accuracy decreases with an increased number of bars.

Results

C - as predicted.

S - as predicted.

PERCEPTUAL GROUPING (Homogeneous, Heterogeneous/Adjacent, and Heterogeneous/Nonadjacent conditions).

Predictions

C - Decreased accuracy from Homogeneous to Heterogeneous conditions.

S - No significant decrease in accuracy from Homogeneous to Heterogeneous conditions.

Results

C - As predicted.

S - Significant decrease in accuracy from the Homogeneous to Heterogeneous conditions.

GOOD FIGURE (changes in accuracy resulting from increases in the number of bars from five to six).

Predictions

C - Unknown.

S - No effect on accuracy.

Results

C - No significant decrease in accuracy from five to six bars.

S - Significant decrease in accuracy from five to six bars in the Heterogeneous conditions.

Table 14b.

Summary of predicted outcomes and actual results for reaction time in normal controls (C) and schizophrenic subjects (S) for the perceptual span, perceptual groupings, and good figure.

PERCEPTUAL SPAN (changes in reaction time resulting from an increase in the number of bars).

Predictions

- C - Reaction time increases with an increased number of bars.
- S - Reaction time increases with an increased number of bars.

Results

- C - As predicted.
- S - Reaction time increased with an increase up to four bars.

PERCEPTUAL GROUPING (Homogeneous, Heterogeneous/Adjacent, and Heterogeneous/Nonadjacent conditions).

Predictions

- C - Increased reaction time from Homogeneous to Heterogeneous conditions.
- S - No significant increase in reaction time from Homogeneous to Heterogeneous conditions.

Results

- C - As predicted.
- S - In general, significant increase in reaction time from Homogeneous to Heterogeneous conditions. Significant Four-way interaction indicates similar reaction times in the grouping conditions when six bars are presented.

GOOD FIGURE (changes in reaction time resulting from an increase in the number of bars from five to six).

Predictions

- C - Unknown.
- S - No effect on reaction time.

Results

- C - No significant increase in reaction time from five to six bars in the Homogeneous condition. Significant increase in reaction time from five to six bars in the Heterogeneous conditions.
 - S - No significant difference in reaction time from five to six bars.
-

indicate that the major differences between schizophrenic subjects and control subjects emerge when the good figure (hexagon) becomes more apparent as the number of bars increases from five to six. These major differences are that: Control subjects do not decrease in accuracy as the number of bars increase from five to six while schizophrenic subjects do decrease significantly in accuracy in the heterogeneous conditions as the number of bars increase from five to six; control subjects do not significantly decrease in reaction time in the homogeneous condition but do show significant increases in reaction time in the heterogeneous conditions as the number of bars increase from five to six. Schizophrenic subjects do not increase significantly in reaction time in any condition as the number of bars increase from five to six.

These findings suggest that a characteristic of schizophrenia is the disruption of perceptual organization.

Analyzed in detail, these results suggest that as a result of the Pragnanz principle (probably a type of closure) caused by the formation of a hexagon when five and six bars were presented, the reaction times of control subjects were significantly slower at five and six bars than those of the schizophrenic subjects. In comparison, the schizophrenic subjects are suggested to

have responded without using additional time for global analysis of the hexagon. This hypothesis is supported by the finding that schizophrenic subjects did not respond with significant increases in reaction time as the number of bars increased from four to six. Both groups of control subjects, in comparison, responded with significant increases in reaction time as the number of bars increased from three to six. These findings are consistent with the Place and Gilmore (1980) and Wells and Leventhal (1984) results. In both of those studies, it was reported that control subjects were significantly more accurate in the Homogeneous condition than in both heterogeneous conditions. The schizophrenic subjects, however, revealed an absence of significant differences in accuracy between the homogeneous and heterogeneous conditions. The findings of group differences as a function of perceptual complexity reported by Place and Gilmore and Wells and Leventhal are best interpreted as due to group differences in perceptual grouping (similarity and proximity), whereas the findings of group differences as a function of number of bars in the present experiment are best interpreted as due to group differences in good figure (continuity, closure, and common fate). Perceptual grouping and good figure represent different (but probably related) aspects of perceptual organization. Good figure may be a stronger

force for wholistic processing than similarity and proximity. The results of the present experiment are consistent with the interpretation that perceptual organization, which depends on global processing, is deficient in schizophrenic persons.

In the present study the finding of significantly less accuracy for the schizophrenic subjects is in sharp comparison to the Place and Gilmore (1980) and Wells and Leventhal (1984; and in press) results. The reasons for the differences in the accuracy data may be attributed to several differences between the present experiment and previous similar studies. One difference between the studies is that in the present experiment white bars were presented on a gray to black background while in previous studies thin black lines were presented on a white background. Eriksen and Collins (1968) reported that black on white stimuli can be organized or integrated in less time than white on black stimuli. Such differences in organization time suggest that these reversed stimuli might not be completely comparable.

Both the Place and Gilmore (1980) and Wells and Leventhal (1984) studies held intensity of the stimulus display constant, but Place and Gilmore (1980) varied the duration of the stimulus display as an experimental parameter while Wells and Leventhal kept the duration constant. The present experiment varied intensity of the

stimulus and kept the duration of the stimulus constant in order to measure threshold. In these studies it was expected that time-intensity reciprocity would hold for the stimulus displays because they were all less than 50 ms. (Bloch's law). However, it is possible that other variables besides stimulus intensity and duration may have differentially influenced the results from what was expected.

The use of higher intensities for the schizophrenic subjects than for the young control subjects may be viewed, as the procedure was intended, as better equating the stimuli across groups. However, even if one were to view the situation as schizophrenic patients receiving visually brighter stimuli than controls, it is hard to see how this would account for less accuracy for the schizophrenic patients. Conceivably though, following this last assumption, receiving brighter stimuli could have resulted in the patients being better able to form good figure, and by that token losing time in a global processing step, and therefore being less accurate. But the reaction time data showing faster reaction times for schizophrenic patients at five and six bars is in conflict with such an interpretation.

In addition, the present study used thicker lines or bars for the stimuli which are of a lower spatial frequency than those used in the Place and Gilmore study.

The thicker bars may have contributed to more local processing of the three perceptual organizational conditions for control subjects. An increased local processing of the perceptual organizational conditions for control subjects in the present study, could be due to the lower spatial frequency of the thick bars and the greater visual angle of the bars forming the hexagon than in the Place and Gilmore study. The use of the bars rather than lines may have had the effect of causing an increased amount of global processing for control subjects directed towards the more definite hexagon form produced by the thick bars used in the present experiment. This effect is in comparison to the amount of global processing of control subjects directed towards the hexagon form produced by the line stimuli of Place and Gilmore (1980). The hexagon becomes most apparent when five or six bars are presented.

It is also possible that the changes in the stimuli of the present experiment affected the focus of perceptual organization. As a result of the differences in stimuli between the present experiment and Place and Gilmore study it is possible that the studies were measuring responses to slightly different dominant aspects of the stimulus display. The difference in results between the Place and Gilmore and the present study may be due in part to the greater contribution of

viewing the display globally as a hexagon and to the decreased contribution of the three perceptual organizational conditions in the present study. The results are consistent with this view.

Another difference between the Place and Gilmore and Wells and Leventhal experiments and the present study is that in the present study two responses were measured i.e., subjects were instructed to respond with both speed and accuracy. Having to respond as fast as possible while being as accurate as possible, may have had a differential effect on the groups. The schizophrenic subjects may have been affected adversely because of the increased burden of having to respond to the two simultaneous requirements of supplying a correct answer and providing it quickly.

The use of the microcomputer may not have been as sensitive to the deficits in perceptual grouping (laws of similarity and proximity) as the tachistoscopic procedure of Place and Gilmore (1980) and Wells and Leventhal (1984). However, the microcomputer had the benefits of portability, ease and speed of stimulus presentation, and record keeping. The differences in apparatus may have contributed to viewing the complex stimuli differently in the different studies, even though the same basic stimulus configurations were used.

Additional Support for Perceptual Organizational Deficit Groups with comparable accuracy. In comparison to the accuracy data obtained in the present experiment, the reaction time data support the perceptual organizational deficit theory of Place and Gilmore (1980). As discussed previously, schizophrenic subjects were significantly faster than young and elderly control subjects for five and six-bar displays. Additional evidence indicates that similar performances were also obtained for subjects selected on the basis of having comparable group accuracy scores.

It is possible that lower accuracy is accompanied by faster reaction times because of responding without the analysis of stimulus input. It was therefore important to establish whether schizophrenic subjects respond with faster reaction times when groups have comparable accuracy scores. In spite of the loss of subjects for these analyses, the results clearly indicated faster reaction times for the schizophrenic subjects with an increase in the number of bars presented. These reaction time results substantially reduce the possibility that the schizophrenic subjects were responding impulsively or "at random".

Reaction times of only correct answers. When reaction times of only accurate responses are compared among the three groups of subjects, the schizophrenic

subjects still responded more rapidly than control subjects as the number of bars increased. The schizophrenic subjects do not show the same increase in reaction time as the control subjects do when the number of bars presented increase to six. The increase in reaction time for control subjects above those of schizophrenic subjects apparently reflects the additional time needed by control subjects for global processing. Reaction times obtained for only correct answers again demonstrate that schizophrenic subjects seem to ignore the good figure caused by the formation of the hexagon, because they are not engaging in global processing.

Four-way interaction. A quadruple interaction was also obtained for reaction times of the three groups of subjects for the four blocks of trials, the three perceptual organizational conditions, and the four different number of bars. These findings suggest that the differences among the groups are due to differences in perceptual processing in that: Schizophrenics display significantly faster reaction times than control subjects when five and six bars are presented; schizophrenic subjects respond with more similar reaction times (although not significant) for the homogeneous and heterogeneous conditions than the control subjects; there is a significant two-way interaction for reaction times of the perceptual grouping conditions and the number of

bars presented in which the increase from five to six bars in the Homogeneous condition was not significant, while the increase in reaction time from five to six bars was significant in the Heterogeneous conditions. In addition, the control subjects seemed to be responding faster to the heterogeneous grouping conditions as the number of blocks increased. The quadruple interaction has therefore been interpreted to mean that the schizophrenic subjects were responding faster than the normal subjects as the number of bars presented increased from five to six particularly for the heterogeneous conditions, but only on the initial blocks of trials.

Faster reaction times for schizophrenic subjects under conditions of increasing organizational demands support the Place and Gilmore (1980) interpretation in terms of a perceptual organization deficit. When the number of bars increases from three to six the Gestalt organizing factors apparently come into play (both the perceptual organizations of the H, HA, and HNA conditions and viewing the display globally as a hexagon), requiring increased processing time, especially for the more perceptually demanding stimuli. The principles of similarity, proximity, and pragnanz apparently are more compelling for normal subjects. Normal subjects automatically take more time to process differences in the perceptual organization of the stimulus display. In

comparison to control subjects, the perception of schizophrenic subjects is less influenced by grouping and good figure so that their reaction times remain uninfluenced by differences in perceptual organization. The reaction times of the schizophrenic subjects therefore become relatively faster than those of control subjects as the number of bars and perceptual grouping complexity increase.

Reported number of bars. Since certain reports in the literature indicated that reaction time was based on the reported number of stimuli rather than the actual number of stimuli (Oyama et al., 1981) and that performance of schizophrenic subjects may be bounded by an upper limit (Neale, 1971), it is possible that schizophrenic subjects respond faster because their reaction times are based on perceiving fewer stimuli as the number of bars increase. This was not evidenced. The mean number of bars reported by the schizophrenic subjects was identical for the Homogeneous and Heterogeneous/Adjacent conditions. The mean number of bars reported by the schizophrenic subjects was greater in the Heterogeneous/Nonadjacent condition than in the Homogeneous or Heterogeneous/Adjacent conditions. The control subjects responded with a decreasing mean number of bars from the Homogeneous to the Heterogeneous/Adjacent to the Heterogeneous/Nonadjacent.

The schizophrenic subjects reported significantly more bars in each condition than the control subjects.

Additional Findings

Practice and fatigue effects. Practice and/or fatigue effects apparently influenced the groups differentially. Differences in accuracy between the normal and schizophrenic subjects became more pronounced as the experiment continued. The young control subjects increased in accuracy from early to later blocks as compared to the schizophrenic subjects who decreased in accuracy from early to later blocks. The differential effects over time for the groups is also seen in the reaction time data. The differences in reaction time among the groups is somewhat reduced by the control subjects' increasingly faster reaction times from early to later blocks of trials. In spite of their decrease in accuracy and increase in reaction time over the session, the schizophrenic subjects were in general faster than the normal subjects as the number of bars and complexity of the display increased.

Differences between sessions. Three significant effects were obtained as a result of retesting. First, accuracy decreased significantly in the second session.

Second, reaction times were faster to the two heterogeneous conditions for all groups in the second

session as compared with the first. The reaction times in the homogeneous display did not change from the first to the second session. The faster reaction times for the heterogeneous conditions in the second session may be the result of some kind of perceptual learning, at least in control subjects, which results in their being better able to bypass the global processing stage.

Third, reaction time was significantly faster for a display of six bars in the second session than in the first. This result may be due again to perceptual learning of control subjects which results in being better able to bypass the global processing stage

These results suggest that the effects of global processing in normal control subjects were decreasing with further exposure to the stimulus displays. Because of the decreased global processing, normal subjects were responding with reaction times more similar to those of schizophrenic subjects. The normal subjects seemed to be engaging in more local detailed processing as a result of practice. This direction of change was not found for schizophrenic subjects.

Other Possible Interpretations of the Results

Impulsivity. The faster reaction times for the schizophrenic subjects could conceivably be due to their impulsivity or responding at random. Impulsivity or

responding "at random" may play some part in the faster reaction times obtained, and it would be expected to result in lower accuracy scores for schizophrenic subjects. On the other hand, when subjects equated for accuracy are compared, reaction times of schizophrenic subjects are still significantly faster than control subjects as the number of bars increased. Furthermore, the faster reaction times obtained for schizophrenic subjects even when only correct responses are considered again tends to rule out the impulsivity explanation. In addition, it is highly unlikely that schizophrenic persons can report the number of bars presented in the stimulus display with such accurate mean responses by chance, since the groups did not differ on the number of bars reported with respect to the number of bars presented.

More efficient processing. Another possible explanation for the faster reaction times of schizophrenic subjects might be that the schizophrenic patients process more efficiently. The schizophrenic subjects may therefore be able to process the perceptual organizational information faster than normal control subjects. Although possible, several aspects of the data are inconsistent with this interpretation. Two findings which can be viewed as being inconsistent with this interpretation are: That schizophrenic subjects were not

significantly faster than control subjects in general, but rather were only faster than control subjects when five and six bars were presented and not when only three and four bars were presented; and that schizophrenic subjects and not control subjects significantly decreased in accuracy in both heterogeneous conditions when the number of bars presented increased from five to six.

In order to determine whether more efficient processing is a viable alternative, the relationships among the perceptual span effect, the perceptual grouping conditions, and seeing the display globally as a good figure (hexagon) must be understood. The perceptual span effect, the perceptual grouping conditions, and seeing the display globally as a good figure all exert their effects on perception. It is not evident a priori which of these is providing the greatest contribution at any given moment. The number of bars counted is directly related to the number of bars presented. It is known from the literature that reaction time increases and accuracy decreases as the number of elements in the display increase (Woodworth & Schlosberg, 1954). The control subjects responded to the increase of the number of bars from five to six, collapsed across conditions, with significant increases in reaction time. In addition, control subjects did not display significant decreases in accuracy from a five bar to a six bar display in any of

the perceptual grouping conditions. If the schizophrenic subjects are more efficient processors it would be expected that reaction times might not increase significantly from the five to six bar display. Indeed, the schizophrenic subjects did not show a significant increase in reaction times from the five to six bar display.

Seeing the display globally as a good figure did not have the same effect on accuracy for the schizophrenic subjects as it did for the control subjects when the number of bars was increased from five to six in the heterogeneous conditions. If the schizophrenic subjects did see the display globally as a good figure, although at a faster processing rate than control subjects, accuracy should be affected in a manner similar to the accuracy of control subjects. Because seeing the display globally as a good figure caused significant decreases in accuracy in the heterogeneous conditions when the number of bars increased from five to six without causing corresponding significant increases in reaction times for the schizophrenic subjects, it appears that the schizophrenic subjects were not processing the perceptual organization of the good figure more efficiently.

Also inconsistent with a more efficient processing hypothesis are reports in the literature suggesting schizophrenic subjects are slower processors rather than

More efficient processors (e.g., Yates, 1966; Braff & Saccuzzo, 1981; Schwartz, Winstead, & Adinoff, 1983).

Speed-accuracy trade-off differences. Differences among groups in terms of the speed-accuracy trade-off could also account for some of the data. When a speed-accuracy trade-off occurs, it is expected that fast responses are associated with a high error rate and slow responses with low error rate (Kroll & Hershenson, 1980; Rosen & Hershenson, 1983). In fact, faster reaction times and poorer accuracy for schizophrenic subjects were obtained in the present study. However, when we go beyond this gross group comparison, the speed-accuracy differences between groups cannot account for the schizophrenic subjects' faster reaction times. Further analyses have indicated that when there are no significant differences among the groups in accuracy or when only correct answer reaction times are compared, schizophrenic subjects still display significantly faster reaction times.

Significant negative correlations between accuracy and reaction time (see pages 90-91) were revealed primarily for schizophrenic subjects. Normal control subjects did not display any correlation between accuracy and reaction time, with the exception of two possibly spurious negative correlations. The negative correlations indicated that as accuracy decreased, reaction time

increased and also as accuracy increased, reaction time decreased. These significant negative correlations and zero correlations are a further indication that a speed-accuracy trade-off cannot account for the results.

However, the speed-accuracy trade-off does seem to operate differently in the two sessions. In the second session, findings of reduced accuracy, faster reaction times, and reporting fewer bars for the Homogeneous and Heterogeneous/Nonadjacent conditions are all consistent with speed-accuracy trade-off differences for the two sessions for all groups.

Implications

It is difficult to determine whether the evidences of a perceptual organizational deficit in schizophrenia reflect an encoding, feedback, or response problem. It has been suggested that schizophrenic subjects may lack an ordered response set, are unable to use pigeonholing (Schwartz, 1982), and are unable to develop priorities when responding to simultaneous elements (Magaro, 1980).

Current theoretical models of information processing add support to the theory that global processing takes place early in processing. This global processing stage is believed to be deficient in schizophrenic subjects. The first stage of information processing is considered the wholistic, automatic perceptual organizer in which

stimuli are processed in parallel (Knight, 1983). The first stage has been described as a high capacity sensory storage which uses spatial position and therefore perceptual organization. This stage can be easily masked, and lasts for about 100 ms. At this stage, the size of the display matrix has little effect on reaction time, suggesting parallel processing (Phillips, 1974).

The first stage has been described as wholistic analysis (Kroll and Hershenson, 1980), sensory storage (Phillips, 1974), the identification process (Potter, 1976), automatic processing (Schneider & Shiffrin, 1977; Shiffrin & Schneider, 1977). This is the stage considered to be one of visual or phenomenal persistence (Coltheart, 1980; Kietzman et al., 1984). The data obtained from various studies of perception in schizophrenia seem to indicate that the perceptual organizational deficit in schizophrenic subjects occurs during this automatic stage of processing (Knight, 1983).

Other recent experiments also indicate that the schizophrenic organizational deficit occurs early in processing (Braff & Saccuzzo, 1985; Schwartz, Winstead & Adinoff, 1983). According to Braff and Saccuzzo (1985), schizophrenic subjects show abnormal information processing in the range of 60 ms and 500 ms.

Knight (1983) suggests that the automatic processing deficit (global processing deficit) makes the controlled

processing (analytic processing) vulnerable to overload. This may explain why some investigators have proposed an impairment of controlled processing in schizophrenic subjects (Callaway & Naghdi, 1982; Neale & Oltmanns, 1980).

A possible way to understand why normal subjects take longer than schizophrenic subjects to respond may be related to automatic vs. controlled processing. According to Shiffrin & Schneider (1977), items that automatically attract attention act to interrupt controlled processing. The automatic responses may act to dominate the controlled processing system and cause attention to be directed to those aspects of the display that should be ignored. According to this model, a loss of time is expected to occur before the control processes are redirected to the primary or relevant aspect of the task. Perhaps the automatic processes do not act to interrupt the controlled processing in schizophrenic subjects as they do in normal subjects.

The present study does not reveal session differences attributable to the therapeutic effects of medication for the schizophrenic subjects. The first testing of the schizophrenic subjects occurred when they were admitted to the hospital. The second testing of these subjects occurred when release from the hospital was imminent. Although the patients were released and still taking

medication, not all of them were completely remitted. Two patients were sent elsewhere for longer term care, four of the patients who had been sent home were not completely recovered, and three of the patients who were sent home were readmitted to the hospital soon after their release. It is not clear whether the perceptual organizational deficits of schizophrenic subjects remain despite medication or because improvement of most of the patients was questionable.

Several other studies have also found that medicated and nonmedicated schizophrenic subjects do not differ on a variety of cognitive tasks (in a masking task, Braff, 1981; in simple motor reaction time, Held, Cromwell, Frank, & Fann, 1970; in a variety of tasks including block design, digit symbol, object assembly, picture completion, embedded figures, rod-frame task, Stroop color-word interference, size estimation, schematizing test, and critical flicker, Killian, Holzman, Davis & Gibbons, 1984).

Apparently performance on some tasks can show improvement (e.g., Wahba, Donlon, and Meadow, 1981; Braff and Saccuzzo, 1982). Performance on the Benjamins proverb test, the digit span with and without distraction and a vocabulary test was improved for patients who were moderately medicated, highly medicated, and for schizophrenic subjects on a standard dosage of medication

as compared to a normal control group. The improvement in these cognitive activities was associated with overall clinical remission (Wahba et al., 1981). The Braff and Saccuzzo (1982) study indicated that information processing for schizophrenic subjects may be speeded up by their medication.

It has been suspected on the basis of clinical interviews that schizophrenic subjects have a difficulty in perceptual organization. Reports by schizophrenic subjects obtained during the onset and course of psychotic episodes suggest difficulty in distinguishing figure from ground. Some schizophrenic subjects are described as being as sensitive to irrelevant background stimuli as they are to figures (Freedman, 1974).

Pronounced changes have been reported by schizophrenic patients in attention and perception; they particularly displayed difficulty in selective organization and in control of incoming information. The patients reported involuntarily attending to background information. They also reported that their actions seemed to be planned and then executed in a step by step manner (McGhie and Chapman, 1961).

The perceptual organizational ability possessed by schizophrenic subjects appears to break down under certain circumstances. It is possible that if processing is inaccurate, slower than normal, or incomplete,

subsequent processing could manifest itself as illogical ideas, irrational behavior, or as disturbances in attention and concept formation (Schwartz & Winstead, 1982). For many years a dysfunction in attention, which may be related to or the same as a dysfunction in processing, has been implicated as an important characteristic of schizophrenia. This processing dysfunction may actually be a perceptual organizational deficit causing difficulties in thinking. It has been suggested that the thought disorder symptom of schizophrenia may be the result of inadequate and distorted incoming information (Cox & Leventhal, 1978). The thought disorder may be caused by more basic deficiencies in processing which normally allow detection and utilization of specific stimulus cues in organizing incoming information (Maruszak & Koh, 1980).

Knight (1983) suggests that the perceptual organizational deficit of schizophrenic subjects is not absolute. Schizophrenic subjects can perform some cognitive tasks. Tasks which depend on serial processing result in more adequate performance of schizophrenic subjects: Full report, Cash, Neale, & Cromwell, 1972; short term task involving numerosity, Koh, Kayton & Streicker, 1976; short term memory scanning and recognition, Koh et al., 1977; visual search, Russell, Considine, & R.G. Knight, 1980; Russell & R.G. Knight,

1977.

Summary

The results of the present study extend the original Place and Gilmore findings to include reaction time. However, better accuracy for schizophrenic subjects under some conditions is not confirmed. The present study obtained results suggesting that additional time was used by control subjects above those obtained for schizophrenic subjects. The additional time used by control subjects was due to viewing the display globally as a hexagon (laws of good figure) and to a lesser extent the three perceptual organizational conditions (Homogeneous, Heterogeneous/Adjacent, and Heterogeneous/Nonadjacent - laws of similarity and proximity). The faster reaction times of the patients becomes understandable based on the interpretation that unlike normal control subjects, the schizophrenic subjects ignored the good figure organization of the visual display. The reaction times of the schizophrenic subjects therefore did not reflect a loss of time due to global processing. Thus, it is suggested that the schizophrenic subjects display either a different type of perceptual processing or an impairment in perceptual organization.

Appendix A

Inclusion and Exclusion CriteriaInclusion Criteria

Normal subjects. Persons were considered normal and accepted into the present study if they did not meet Research Diagnostic Criteria (RDC) for any episodes of psychopathology.

Schizophrenic subjects. Subjects who met the RDC for any of the following subtypes of schizophrenia were included in the study: Paranoid, Disorganized, Catatonic, Undifferentiated, or Residual Schizophrenia. An agreement between the RDC diagnosis and the Psychiatrist's DSM-III was necessary for inclusion in the present study. In addition, persons who were exhibiting schizophrenic symptoms and who had a history of manic or depressive symptoms prior to three months before the onset of the present episode of schizophrenia were also included.

The RDC for the diagnosis of Schizophrenia is listed below:

A through C are required for the period of illness.

A. During the active phase of illness (may or may not now be present) at least two of the following are required for definite and one for probable:

- (1) Thought broadcasting, insertion, or withdrawal.

- (2) Delusions of being controlled (or influenced), other bizarre delusions or multiple delusions.
 - (3) Somatic, grandiose, religious, nihilistic, or other delusions without persecutory or jealous content lasting at least one week.
 - (4) Delusions of any type if accompanied by hallucinations of any type for at least one week.
 - (5) Auditory hallucinations in which a voice keeps up a running commentary on the subject's behaviors or thoughts as they occur, or two or more voices converse with each other.
 - (6) Non-affective verbal hallucinations spoken to the subject.
 - (7) Hallucinations of any type throughout the day for several days or intermittently for at least one month.
 - (8) Definite instances of marked formal thought disorder accompanied by either blunted or inappropriate affect, delusions or hallucinations of any type, or grossly disorganized behavior.
- B. Signs of the illness have lasted at least two

weeks from the onset of a noticeable change in the subject's usual condition (current signs of the illness may not now meet criterion A and may be residual symptoms only, such as extreme social withdrawal, blunted or inappropriate affect, mild formal thought disorder, or unusual thoughts or perceptual experiences).

C. At no time during the active period (delusions, hallucinations, marked formal thought disorder, bizarre behavior, etc.) of illness being considered did the subject meet the full criteria for either probable or definite manic or depressive syndrome (criteria A and B under Major Depressive or Manic Disorders) to such a degree that it was a prominent part of the illness.

Exclusion Criteria

Any diagnosis other than that of Schizophrenia or Schizophreniform (Schizophrenia with less than six months of symptoms) were excluded from the study. The exclusion of subjects based on the diagnosis of a Schizo-Affective disorder was determined by RDC criteria as follows:

Schizo-affective, depressed type (must meet both criteria A and B listed below within three months of the onset of Schizophrenia).

A. One or more distinct periods with dysphoric mood or pervasive loss of interest or pleasure. The disturbance must be a major part of the clinical

picture.

B. At least four of the following symptoms are required for probable diagnosis:

- (1) Poor appetite or weight loss or increased appetite or weight gain.
- (2) Sleep difficulty or sleeping too much.
- (3) Loss of energy, fatigability, or tiredness.
- (4) Psychomotor retardation or agitation.
- (5) Loss of interest or pleasure in usual activities, including social contact or sex.
- (6) Feelings of self-reproach or excessive inappropriate guilt.
- (7) Complaints or evidence of diminished ability to think or concentrate, such as slowed thinking, or indecisiveness.
- (8) Recurrent thoughts of death or suicide, or any suicidal behavior.

Schizo-affective, manic type (must meet criteria A and B listed below within three months of the onset of Schizophrenia).

A. One or more distinct periods with a predominantly elevated, expansive, or irritable mood.

B. If mood is elevated or expansive at least two of the following symptom categories for probable diagnosis,

three if irritable.

- (1) More active than usual-either socially, at work, at home, sexually, or physically restless.
- (2) More talkative than usual or felt a pressure to keep talking.
- (3) Flight of ideas or subjective experience that thoughts are racing.
- (4) Inflated self-esteem
- (5) Decreased need for sleep
- (6) Distractibility
- (7) Excessive involvement in activities without recognizing the high potential for painful consequences.

Other subject exclusion criteria were alcoholics, persons on any CNS drugs (other than the anti-psychotic medication given to the schizophrenic patients), persons who have received ECT within the last year, persons with any evidence of organic mental problems, and control subjects with any prior evidence of any mental illness. Subjects are to have a normal or corrected normal visual acuity of 20/30 or better, as determined by the use of the Snellen chart.

Appendix B
Instructions

These instructions are to be given for both procedures (threshold determination and main experiment).

The first part of the experiment should take about thirty to forty five minutes. The second part of the experiment should take one to two hours. You are going to be presented with pictures of bars. The bars will be either all vertical, all horizontal, or both vertical and horizontal.

When we are ready to begin I will say ready and press the space bar on the computer. Shortly after I press the bar, a fixation dot will appear on the screen. Look at the dot when it appears. The dot is there so that you can look at that part of the screen where the bars will appear. Immediately after the dot disappears the bars will flash on the screen. As soon as you know how many bars there were, call out the number of bars.

Please respond as fast as you can but be as accurate as possible. After you have called out the number of bars the dot will reappear to mark the end of the trial. If you miss the trial for

any reason remain silent so that you do not activate the microphone. That trial will reappear later in the session.

Appendix C

Summary of ANOVA of arc sin transformed proportion correct for the
combined first and second sessions.

Source	df	SS	MS	F
G	2	288.7842	144.3921	8.23 **
A	3	9.2547	3.0849	.91
A x G	6	65.1434	10.8572	3.19 **
B	3	77.5452	25.8484	17.35 **
B x G	6	8.5063	1.4177	.95
A x B	9	7.6832	0.8537	1.27
A x B x G	18	14.9314	0.8295	1.23
C	2	83.1084	41.5542	41.91 **
C x G	4	9.2803	2.3201	2.34
A x C	6	2.6833	0.4472	.61
A x C x G	12	8.3141	0.6928	.94
B x C	6	6.8462	1.1410	2.01
B x C x G	12	18.5728	1.5477	2.73 **
A x B x C	18	9.0927	0.5052	.86
A x B x C x G	36	26.2467	0.7291	1.25
D	1	11.1748	11.1748	15.65 **
D x G	2	1.0174	0.5087	.71
A x D	3	0.8822	0.2941	.54
A x D x G	6	3.4289	0.5715	1.05
B x D	3	0.6370	0.2123	.31
B x D x G	6	2.2196	0.3699	.54
A x B x D	9	6.4287	0.7143	1.23
A x B x D x G	18	12.9970	0.7221	1.25
C x D	2	2.4830	1.2415	1.78
C x D x G	4	3.6135	0.9034	1.30
A x C x D	6	1.3062	0.2177	.31
A x C x D x G	12	7.5267	0.6272	.89
B x C x D	6	0.4526	0.0754	.10
B x C x D x G	12	2.5055	0.2088	.27
A x B x C x D	18	14.7409	0.8189	1.36
A x B x C x D x G	36	23.2615	0.6462	1.07

Key to Table

A	:	Blocks	* p<.05
B	:	Number of bars	** p<.01
C	:	Condition	
G	:	Group	
D	:	Session	

For the sake of clarity error terms are not shown. Epsilon corrected.

Appendix D

Summary of ANOVA of Log(Base 10) reaction times for the first and second sessions.

Source	df	SS	MS	F	
G	2	0.3507	0.1753	0.26	
A	3	0.2289	0.0763	1.37	
A x G	6	0.2759	0.0460	0.83	
B	3	5.7315	1.9105	117.16	**
B x G	6	6.675	1.113	5.34	**
A x B	9	0.0674	0.0075	1.19	
A x B x G	18	0.1004	0.0056	0.88	
C	2	1.1324	0.5662	64.66	**
C x G	4	0.0529	0.0132	1.51	
A x C	6	0.0195	0.0033	1.06	
A x C x G	12	0.0296	0.0025	0.80	
B x C	6	0.1284	0.0214	3.37	**
B x C x G	12	0.0419	0.0035	0.55	
A x B x C	18	0.0459	0.0026	0.79	
A x B x C x G	36	0.1884	0.0052	1.62	*
D	1	0.2248	0.2248	56.86	**
D x G	2	0.0031	0.0015	0.39	
A x D	3	0.0108	0.0036	0.87	
A x D x G	6	0.0296	0.0049	1.19	
B x D	3	0.0627	0.0209	4.29	**
B x D x G	6	0.0138	0.0023	0.47	
A x B x D	9	0.0291	0.0032	0.91	
A x B x D x G	18	0.0761	0.0042	1.20	
C x D	2	0.1620	0.0810	24.76	**
C x D x G	4	0.0144	0.0036	1.10	
A x C x D	6	0.0122	0.0020	0.69	
A x C x D x G	12	0.0415	0.0035	1.16	
B x C x G	6	0.0303	0.0050	1.44	
B x C x D x G	12	0.0307	0.0026	0.73	

Key to Table

A : Blocks
 B : Number of bars
 C : Condition
 G : Group
 D : Session

* $p < .05$ ** $p < .01$

For the sake of clarity error terms are not shown. Epsilon corrected.

Appendix E

Summary of ANOVA of Log(Base 10) transformed RTs for the seven schizophrenic, eight young normal, and eight elderly normal subjects.

Source	df	SS	MS	F
G	2	0.3812	0.1906	.47
A	3	0.1076	0.0359	2.96
A x G	6	0.1461	0.0243	2.01
B	3	3.7545	1.2515	70.19 **
B x G	6	0.3498	0.0583	3.27 *
A x B	9	0.0644	0.0072	1.81
A x B x G	18	0.0512	0.0029	0.72
C	2	0.0411	0.0205	5.72 **
C x G	4	0.0059	0.0015	.41
A x C	6	0.0171	0.0029	1.05
A x C x G	12	0.0225	0.0019	.69
B x C	6	0.0176	0.0029	.71
B x C x G	12	0.0396	0.0033	.80
A x B x C	18	0.0328	0.0018	.49
A x B x C x G	36	0.1086	0.0030	.80

Key to Table

A	:	Blocks	*	p<.05
B	:	Number of bars	**	p<.01
C	:	Condition		
G	:	Group		

For the sake of clarity error terms are not shown. Epsilon corrected.

Appendix F

Summary of ANOVA of LOG(Base 10) transformed RTs for the second session for five schizophrenic, seven young controls, and seven elderly controls.

Source	df	SS	MS	F	
G	2	0.3206	0.1603	.41	
A	3	0.1145	0.0382	4.26	*
A x G	6	0.0641	0.0107	1.19	
B	3	2.8203	0.9401	75.19	**
B x G	6	0.0694	0.0116	.92	
A x B	9	0.0087	0.0010	.28	
A x B x G	18	0.0714	0.0040	1.14	
C	2	0.0025	0.0013	.34	
C x G	4	0.0127	0.0032	.88	
A x C	6	0.0091	0.0015	.52	
A x C x G	12	0.0169	0.0014	.48	
B x C	6	0.0164	0.0027	.78	
B x C x G	12	0.0473	0.0039	1.12	
A x B x C	18	0.0386	0.0021	.75	
A x B x C x G	36	0.1797	0.0050	1.74	**

Key to Table

A	:	Blocks	
B	:	Number of bars	* p<.05
C	:	Condition	** p<.01
G	:	Group	

For the sake of clarity error terms are not shown. Epsilon corrected.

Appendix G

Summary of ANOVA of Log(Base 10) transformed RTs of only correct answers.

Source	df	SS	MS	F
G	2	0.2106	0.1053	1.27
B	3	1.0442	0.3481	50.69 **
B x G	6	0.0929	0.0155	2.26 ***
C	2	0.0142	0.0071	4.40 *
C x G	4	0.0034	0.0008	.52
B x C	6	0.0185	0.0031	2.03
B x C x G	12	0.0102	0.0009	.56

Key to Table

A	:	Blocks	*	$p < .05$
B	:	Number of bars	**	$p < .01$
C	:	Condition	***	$p = .07$
G	:	Group		

For the sake of clarity error terms are not shown. Epsilon corrected.

Appendix H

Summary of ANOVA of reported number of bars for the first and second sessions.

Source	df	SS	MS	F
G	2	7.1348	3.5674	0.60
D	1	1.9110	1.9110	0.98
D x G	2	2.5388	1.2694	0.65
B	3	718.5492	239.5164	605.92 **
B x G	6	0.6781	0.1130	0.29
D x B	3	0.2522	0.0841	0.50
D x B x G	6	0.4784	0.0797	0.48
C	2	0.0149	0.0074	0.10
C x G	4	0.9140	0.2285	2.98 ***
D x C	2	0.4426	0.2213	3.77 *
D x C x G	4	0.3210	0.0803	1.37
B x C	6	0.3685	0.0614	0.90
B x C x G	12	1.2278	0.1023	1.50
D x B x C	6	0.2771	0.0462	0.55
D x B x C x G	12	1.0581	0.0882	1.05

Key to Table

B : Number of bars
 C : Condition
 G : Group
 D : Session

* $p < .05$
 ** $p < .01$
 *** $p = .05$

For the sake of clarity error terms are not shown. Epsilon corrected.

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