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Perceptual deficits in schizophrenia and other psychotic disorders: A cognitive approach

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PERCEPTUAL DEFICITS IN SCHIZOPHRENIA AND OTHER PSYCHOTIC DISORDERS: A COGNITIVE APPROACH

by

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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.

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Abstract

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by

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Cognitive dysfunctions are fundamental to schizophrenia. Cognitive models illustrate that normals use dual processes—a global, perceptual process (stage one) followed by analytic and abstractive processes (STVM). Prior research found schizophrenics disregarded Gestalt properties of stimuli and outperformed controls on numerosity tasks. This suggested that schizophrenics have a specific, perceptual organization, early-information processing deficit that benefits them on analytic processing tasks. This study examines the performance of 8 acute and 16 chronic schizophrenics, 7 bipolar and 10 non-bipolar, mostly schizoaffective, psychotics, and 22 college and 16 hospital controls, via the *same* stimuli, in a number task (requiring analytic processing of 4, 5, or 6 dot patterns) and a form identification task (requiring holistic processing of square, rectangular or rhombic dot shapes). Three delay intervals between the stimulus offset and the cue to respond measured temporal processing. Patients were drug free and SCID diagnosed. Groups didn't differ in age, nor in number of previous hospitalizations. Four essential results confirm that our tasks tap different information processes, and patients and controls perform differentially. Delay improves controls' accuracy and decreases schizophrenics' accuracy on number processing ($p < .03$). Schizophrenics' performance doesn't decline with more dots on the *number* task ($p > .83$), but controls' accuracy drops significantly ($p < .03$). All patients improve ($p < .02$) on perceptual *form* judgements, when shapes have more dots (i.e., additional cues). Schizophrenics are twice as impaired, and bipolars four-fold worse ($p < .0001$) on form than on number, relative to controls. The pattern of results support dual processing predictions for the control subjects and highlight specific deficits in each of the two stages for schizophrenics. Schizophrenics' performance both confirms and rebuts Place and Gilmore (1980). While prior literature places schizophrenics' deficits at the earliest stage, this research provides evidence for deficits at *both* the perceptual stage and the attentional allocation and consolidation stage. Contrary to previous findings, global processing deficits are ameliorated by enhancements and training. Affective psychotics, particularly bipolars, are both better and worse than schizophrenics on number and form processing respectively. State-trait differences may account for performance deficits in affectives. The pattern of results rebut Chapman and Chapman's (1973) generalized deficit hypothesis of attentional dysfunctions in schizophrenics.

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INTRODUCTION

Information Processing Models

The hypothesis that some cognitive or attentional dysfunction is an important distinguishing characteristic of schizophrenia has existed since the earliest formulations of this disorder (Bleuler, 1950; Kraepelin, 1971). Over the ensuing decades, the construct of attentional deficit spurred a multiplicity of experiments (Asarnow & Sherman, 1984; Collins, Kietzman, Sutton, & Shapiro, 1978; Erlenmeyer-Kimling & Cornblatt, 1978; Gur, 1978; McGhie & Chapman, 1961; Neale, 1971; Shagass, 1976; Yates, 1966) among many others. While the earlier studies suffered because they were unspecific and vague, the attentional measures and outcomes in the latter studies were frequently diverse and divergent from each other. Thus while a large body of literature was accumulating and demonstrating that schizophrenics were compromised in numerous areas of functioning, little convergence or headway in understanding the underlying nature and mechanisms of this very costly and devastating disorder was achieved. During the last decade or so, this situation has been addressed and has begun to be redressed by numerous investigators (e.g., Braff, 1981, 1989; Braff & Saccuzzo, 1985; Kietzman, Spring & Zubin, 1980, 1985; Knight, 1984; Knight, Elliott & Freedman, 1985; Knight, Sherer, Putchat & Carter, 1978; Mannuzza, 1980; Neuchterlein & Dawson, 1984) operating within an information processing framework.

Given the rise in the legitimacy and validity of cognitive psychology, the need to articulate the conceptual basis of cognition as it relates to psychopathological functioning has become increasing clear. Concomitantly, the information processing paradigm has emerged as the dominant conceptual approach in experimental cognitive psychology (Anderson, 1980; Ingram, 1986). Briefly stated, information processing tracks the flow of information from stimulus input to behavioral response via a series of processing stages and control procedures that transform and transfer the input. This model of the flow of information through a human processing system seems uniquely suited not only to investigations of normal cognitive processes, but to analyses of pathological cognition as well (Kietzman, Spring, & Zubin, 1985; Kietzman, Zubin, & Steinhauer, 1984). This research is concerned with the application of an information processing approach to experimental psychopathology, with a particular focus on a subset of psychopathological cognition, namely, visual perceptual information processing in schizophrenic patients.

Information processing can be conceptualized as an overarching framework for modelling the flow of information through a system which consists of a series of processing stages and control processes that guide or modify the transformations and transfers between stages from stimulus input to behavioral response. An external, environmental stimulus, or an internally generated one, initiates a sequence of processing (stages) through which the information is "transduced, selected, coded, stored, and transmitted through the central nervous system" and "eventuates in some kind of final response" (Kietzman, Spring, & Zubin, 1985, p. 157). This model of mind views the individual as an information processing system. Juola (1986) states that humans are active processors of information in that every behavior (from the simple recognition of common objects to the complex participation in conversation), involves the operation of a number of systems working in concert. Neisser (1967) likewise emphasizes the creative, constructive processes that occur within the individual between the advent of the stimulus and the response to it.

As the operations of each stage (i.e., encoding, storage, or retrieval) are completed, the output is passed on to the next stage. Though the basic notion is of a linear, successive progression from stimulus apprehension through increasingly complex and more central processing, there are at least two variations on this basic theme. Firstly, not all stimuli require or warrant depth of processing (Craik & Lockhart, 1972). Depending on either task or stimulus characteristics, transformations and encoding of the information may just proceed to an early stage and not be processed further for more permanent memory storage (LTM) or even for short-term memory (STM). Alternatively, the apprehension of an incoming stimulus may activate memory retrieval and comparisons "culminating in some decision to respond or to sample more data from the environment, or to retrieve more information from memory" (Juola, 1986, p. 51). Additionally, sometimes an internally generated stimulus or expectation in fact guides the apprehension of some external stimulus.

Human information processing can be profitably conceptualized as providing an organizing theoretical framework associated with theoretical constructs, research methodologies, and empirical findings. Ingram and Kendall (1986) argue that information processing should be viewed as a "broad conceptual paradigm," (p. 5) rather than a model or theory, because it subsumes multiple theories of human cognitive functioning. These include models of normal cognition such as Schneider and Shiffrin's (1977, Shiffrin &

Schneider, 1977) "controlled and automatic processing modes," Craik and Lockhart's (1972) "depth of processing," or Kroll and Hershenson's (1982) "two-stage visual processing" model among many others.

Given that direct observation and measurement of "mental activity related to our perceptions, thoughts and actions" (Juola, 1986, p. 51) is inaccessible, inferences regarding the content and operations of mental phenomena must serve in lieu. Information processing's strength is that it is a model of the flow of information through the system over time. By sampling and monitoring behavior (responses) at various time points along the temporal continuum, one gains insight and can formulate theory regarding the stages and processes of mental processing. Such monitoring and sampling refines cognitive theory, and improved theory in turn guides future empirical investigations. The very ability to define specific sequential stages and operations makes information processing such a powerful and practical tool. In response to the naysayers who decry this specificity and analysis as narrow, artificial or lacking in ecological validity (Neisser, 1976), Juola (1986) and other cognitive scientists suggest "it is far better for a theory to be wrong than to be vague," (p. 52) and far better for it to be falsifiable than not. Moreover, this merger between theory and experimental investigation has contributed to making information processing a current dominant force in studying normal cognitive processing. It seems even more advantageous and suited to investigating psychopathological cognitive functioning. Obviously one must first obtain a baseline of what is appropriate normal cognitive functioning. One could then compare performance differences either between normal controls and psychiatric patients, or within the psychiatric spectrum.

The explicitly detailed and quantitative models of information processing seem ideal for obtaining fine-grained analysis of areas of deviant as well as intact functioning in psychiatric groups. This model allows for the precise specification of: (a) the nature of impairments of different psychiatric groups; (b) where along the processing continuum the deficits lie; and (c) the degree of differential deficit (either among differently diagnosed psychiatric groups, or between normal and psychiatric groups). This application of experimental psychology to clinically-relevant concerns is important on several levels. Firstly, it addresses Neisser's (and others') concern over ecological validity and narrowness of focus, by merging experimental methodology and objectivity with real-life clinical issues. Perhaps, more importantly, it provides bridges for understanding among clinicians and researchers, as well as groundwork for a unified approach to assessing and eventually designing appropriate treatments and interventions.

Stages and Processes Formulations. To demonstrate the relevance of this model to psychopathological research, it is necessary to first outline its use in normal cognition. Different investigators utilize different taxonomies when modelling information processing (flow). While Ingram and Kendall (1986) propose that "cognition can be viewed as consisting of several interrelated but conceptually distinct components" (p. 11), Juola (1986) focuses primarily on the content-process dimension of mind, and Kietzman, Spring, and Zubin (1980, 1985) prefer to dichotomize information processing along the three traditional domains of sensation, perception, and cognition. These varying derivative taxonomies illustrate, simultaneously, both complexity and overlap within the information processing model. This redundancy is not a drawback, but rather confirms the utility of such a model.

The formulations of Ingram and Kendall (1986) include four main classes of cognitive variables, namely, structures, propositions, operations and product categories. They define the structural component as representing the architecture of the system, wherein information is stored, organized and represented. Some examples of structure include the constructs iconic memory, STM, LTM, and memory nodes. Cognitive propositions refer to the information that is stored or represented (within the structures), or in Juola's and others' taxonomies, the content of the structures. Some representative propositional constructs include semantic and episodic memories. Cognitive operations refer to the various procedures by which the various components interact to function in processing information. This category is most similar to the widely-accepted processes dimension in other formulations. Examples of operations include constructs such as encoding, spreading activation, retrieval, attention, and speed of information transfer. Cognitive products refer to the end-product, that is, the results of the interactions of the prior categories, and include the decisions, thoughts, attributions and accessed beliefs of the individual that contribute to his response or behavior. These main components are viewed as "reciprocal, interactional and multi-directional" (Ingram & Kendall, 1986, p. 12) in their effects on each other.

Both Juola (1986) and Kietzman et al. (1980, 1985) amplify Ingram's classification of major cognitive components. When considering the structural/functional aspect, it is useful to compare and contrast the three traditional memory stores, namely sensory memory, STM, and LTM. Sensory memory, also known as iconic (visual) or echoic (auditory) memory, is the earliest occurring, has a large capacity store, most likely contains a veridical representation of the stimulus, but persists for a very short duration, perhaps 500 to 1000 ms. STM, also known as immediate or working memory, has limited capacity, and a brief duration of several seconds (without rehearsal) or relatively longer duration with rehearsal or repetition. LTM is characterized as a virtually unlimited, large capacity store which is relatively permanent in duration. In addition, STM and LTM have been contrasted on the relative accessibility of their memories, on their encoding format, and on the nature of forgetting (Juola, 1986).

In a related vein, Kietzman and colleagues (1980, 1985), use the three traditional domains of processing, namely, sensation, perception, and cognition, to outline either structural or processing components. They suggest that answers to "what is being processed" and "where" and "when" refine the structural/functional underpinnings; answers to "how" and "how much" relate to the processes/operations which control and transfer the incoming information. According to Kietzman, Spring, and Zubin (1980, 1985) each domain reflects a different processing time frame and seems most sensitive to particular types of stimuli. Thus the sensory domain is briefest, occurs immediately and lasts maximally up to one second thereafter; the perceptual domain lasts for up to five seconds post stimulus offset; and the cognitive processing domain lasts longest, depending on characteristics of the stimulus and ensuing processes.

Stimuli can be characterized with respect to their physical or informational content. Stimuli that are primarily responded to on the basis of a psychophysical parameter, for example, brightness, intensity, or frequency are processed in the sensory domain; on the other hand, stimuli that are primarily informational, involving verbal or symbolic significance, are processed in the cognitive domain. Stimuli that have both energy and informational components lie somewhere in between and are processed in the perceptual domain. Examples of the types of stimuli processed in each domain might respectively include flashes of light or different tones (sensory); lines, dots, angles, and patterns of sound (perceptual); and CVCs, words, or meaningful stimuli (cognitive). Tasks reflective of these domains include, respectively, Sperling's (1960) classic partial/whole report procedure, visual masking, and signal detection; pattern recognition, dichotic shadowing, and perceptual organization; and span of immediate memory, serial recall, and tasks requiring semantic or conceptual processing.

The issue of "where" processing takes place refers to the level of processing—either in the sense of stage, or in the sense of peripheral versus central processing—which one attempts to assess with experimental designs or procedures. Alternatively, it refers to a neurophysiological substrate for the loci of processing.

"When" processing emphasizes the concept that all information processing procedures must incorporate a temporal dimension. Studies that either manipulate or measure time, yield information as to which type of processing is being tapped.

Regardless of one's formulation of the nature of the structural component as actually a hard-wired, hardware component or simply a functional analogue thereof in describing what is registered and where, processing must also be defined in terms of the control procedures that operate on the incoming information. Control processes are responsible for the transduction, selection, categorization, encoding, transfer, rehearsal and retrieval of information. These processes can be viewed as the software or programs that govern the flow of information. They are more transitory than the structural component, are (usually) more modifiable, and are (or may be) different for different individuals based on their histories, expectancies (Neisser, 1967) and perhaps cognitive styles.

Within the information processing paradigm, several theorists have conceptualized the nature of these processes or operations. Amongst them are top-down/bottom-up distinctions (Norman & Bobrow, 1975), also known as conceptually-driven/data-driven approaches (Lindsay & Norman, 1977). Data-driven versus conceptually-driven models stratify along the sensory to cognitive continuum respectively, and can be considered somewhat isomorphic to them. For example, Kietzman and colleagues' (1985) clever adaptation of signal detection theory sheds light on the differences between data-driven and conceptually-driven processing. "Signal detection theory provides two orthogonal response measures, namely, a measure of sensitivity called *d'* which reflects the ability to sense and discriminate (among) incoming stimuli, and a measure of response bias called beta, which reflects the readiness of the subject to make a given response" (Kietzman et al., 1985, p. 161). The *d'* measure is dependent on the discriminability of the stimuli, namely, on inherent characteristics of the stimuli, which activate data-driven or bottom-up processing. Similarly, beta reflects attributes of the perceiver, such as the cost-benefit ratio one adopts, one's attitude, motivation, understanding of the instructions, and the strategies available to the organism. These derive from the individual's internal state and guide the interpretation of incoming stimuli. They can be viewed as conceptually-driven or as top-down processing because they proceed from the perceiver's prior knowledge and expectation toward the environmental stimulus. "It should be clear that bottom-up or top-down processing alone would be insufficient. The burden of data would be unbearable if we only processed information in a bottom-up manner. And if we only used top-down processing we would always be hallucinating" (Anderson, 1980, p. 48). The two approaches must combine for (effective) processing to occur.

Some theorists have concerned themselves not with processes across domains but within one domain or another. Examples include Craik and Lockhart's (1972) levels of processing model (any domain), Kroll and Hershenson's (1980) and Rosen and Hershenson's (1983) two-stage visual processing model (sensory/perceptual domain) and Paivio's (1971) and Tulving's (1972) dual-code models illustrate processing within the cognitive domain.

In spite of the utility of content-process distinctions in partitioning information processing models, several analogous concepts can be applied to both. Thus, parallel to the capabilities and constraints which exist in the structural dimension, there are capacity and limitation considerations with regard to control processes. Similarly, divisions between sensation, perception, and cognition are also useful in delineating specifics of the various control processes. In distinguishing between sensory and perceptual processing, it is commonly accepted that the former is more neurophysiologically determined, unconscious and automatic. The latter is a conscious, more interpretive process that derives from the "combination of the environmental stimulus and the individual's relevant knowledge, expectations, affective states and goals" (Juola, 1986, p. 59), which in turn derive or activate (in feedback-loop fashion) cognitive processes.

Attention and Processing. Making sense of the continual mass of stimulation which surrounds one requires mechanisms that effectively select among inputs or allocate attention and processing capacity. Attention is a control procedure that is important both in terms of processing capacity and selective processing. Attention can be either voluntary or involuntary, reflecting both the direction of the flow of information processing as well as the demands it places on processing capacity. Voluntary attention is focused, directed attention that is initiated by a subject's expectations, goals and desires. This type of attention is essentially internally (or conceptually) driven. Hence, the flow of processing is from the cognitive domain towards the sensory domain in searching for, or attending to, particular aspects of an incoming stimulus. By contrast, involuntary attention is passive or effortless, and is initiated by the stimulus itself. An unexpected, novel stimulus, or one with particular motivational or situational salience (i.e., for hunger or danger) captures the subject's attention. This type of stimulus suggests externally (or data) driven processing, because characteristics of the stimulus determine the sequence and levels of processing from the sensory through the perceptual to the cognitive domain.

Schneider and Shiffrin (1977, 1985), and Shiffrin and Schneider (1977, 1984), have suggested that control processes can be differentiated on the basis of whether they are taxing or sparing of processing capacity. They distinguish between automatic and controlled processes. Responses to a stimulus that are highly practiced, overlearned, and that proceed without much conscious intention are considered automatic. Additionally, automatic processes ought not to interfere with ongoing mental activity. The greatest advantage for the organism is that it places few demands on a limited capacity. When a variety of processing sequences are well learned, it is possible to automatically process and respond to a range of events simultaneously without the effort of voluntary attention. Thus, automaticity frees one's limited processing capacity to deal with events in the environment that require conscious effort and voluntary attention (Kietzman et al., 1985; Shiffrin & Schneider, 1977, 1984).

Controlled processes are deliberate and reflect conscious effort. Voluntary attention is a type of controlled process that reflects top-down processing and is highly demanding of processing capacity (Kietzman et al., 1985). For example, when learning a new skill one has to expend considerable effort and attention to the many disparate aspects of the task. Any distractor is highly annoying and disruptive. However, with considerable practice, the components can be executed smoothly with little thought or attention. The process has, in effect, become automatic. In fact, with additional practice and skill, one can carry out several automated sequences, such as driving and conversing, simultaneously. Moreover, once they have become automatic, the sequences are relatively inflexible; and one may find it hard to adequately describe the individual components of the skill.

Experimental Psychopathology

Hypotheses regarding attentional deficits in schizophrenia have existed for a very long time. They have been demonstrated both in schizophrenics proper and in others perhaps vulnerable to the disorder—for example, in nonpsychotic schizotypic individuals (Spaulding, 1978; Steronko & Woods, 1978), in schizotypal patients (Balogh & Merritt, 1987; Braff, 1981), and in groups of high-risk children (Asarnow, Steffy, MacCrimmon, & Cleghorn, 1978; Erlenmeyer-Kimling & Cornblatt, 1978). There is, however, relatively little agreement as to which tasks measure attention, and even less consensus as to the processes that may underlie such an all-encompassing term. Hence it seems preferable to restrict oneself to procedures that employ information processing constructs which are precise and well-defined; and which occur early in the processing chain. Some investigators who share this view and have implemented this approach in their research include Knight, Elliott and Freedman (1985); Knight, Elliott and Hershenson, 1991a, 1991b; Neuchterlein and Dawson (1984); and Weiner, Opler, Kay, Merriam and Papouchis (1990).

Three categories of empirical research illustrate the application of an information processing approach to research on attention in schizophrenia. These include backward masking, span of apprehension, and perceptual organization. The basis for focusing on these three mini-paradigms is twofold. Firstly, they each occur at an early stage of visual information processing. A necessary first step in teasing apart schizophrenics' attentional deficits involves determining the adequacy of the structures and processes which are operative early in the processing chain, so as to correctly locate and link deficits in behavior with the aberrant underlying mechanism(s). Otherwise, performance decrements in, for example, a memory task might be erroneously attributed to a dysfunctional memory retrieval system (i.e., a higher order, later occurring cognitive process) when perhaps the initial registration of the stimuli was faulty. Secondly, these measures have been suggested as potential vulnerability markers by their proponents. Zubin (1985) believes that, whereas previously demonstrations of performance differences between schizophrenics and normals were, themselves, an achievement, it has now become imperative to find where, in what time period, and how the deviations relate to both preceding and succeeding processing. Information processing procedures that address deviations in information reception and transmission are clearly important in the systematic search for markers.

Zubin and colleagues (Zubin, 1985; Zubin & Spring, 1977; Zubin, Steinhauer, Day, & van Kammen, 1985) have proposed that schizophrenia might be more adequately considered as a series of punctuated episodes of illness and wellness, rather than one long, chronic illness with gradual, progressive deterioration. Hence one should ideally be able to identify and specify when, under what circumstances, and in which individual an episode is likely to occur, and what the indicators are that the episode has terminated. Markers that indicate vulnerability (i.e., susceptibility) to an episode are called episode markers and are considered state markers. On the other hand, tasks that discriminate individuals who are between episodes, or prior or subsequent to an episode, are measures of trait vulnerability markers. These latter measures of vulnerability should ideally be present in individuals at risk for developing schizophrenia (i.e., high-risk groups), and in schizotypal and remitted individuals as well. Additionally, true measures of vulnerability must discriminate between those diagnosed as schizophrenic and those suffering from other psychotic disorders, for example manic-depressive illness. Each of the three laboratory measures will be defined, and supporting evidence of schizophrenic deficit will be presented.

Backward Masking. Visual backward masking procedures involve the presentation of two brief stimuli separated in time. One stimulus is the test or target stimulus, and the other is a noise stimulus. The nature of the noise stimulus can vary, and it can be either meaningful or meaningless. The interval between stimuli, known as the inter-stimulus interval (ISI), can be varied from as little as zero ms to several hundred ms. In general, longer ISIs produce less and less masking until effectively there is no mask or interference from the noise stimulus. When the mask occurs subsequent to the target stimulus, it is called backward masking because the second stimulus works backwards to mask the effects of the first. In structured backward masking, a meaningless patterned mask follows the target and appears in the same location as the target. In metacontrast backward masking, the mask likewise follows the target, but is juxtaposed rather than superimposed on the target locus (Knight, p. 33, 1991, in press-b). In all these variations, determining the intervals that either maximize or minimize masking allows one to draw inferences regarding iconic memory; for example, regarding the strength and stability of the icon, its duration, decay rate and so forth. When a short interval (e.g., 50 ms) exists between mask and target, performance is at chance; as the ISI is extended, performance improves. This occurs because the masking effects are lessened, and information from the sensory store has been encoded and transferred to more perceptual and conceptual representations (Loftus, Hanna, & Lester, 1988).

Saccuzzo and Braff (1981; Braff & Saccuzzo, 1981; Miller, Saccuzzo & Braff, 1979) have investigated backward masking in numerous studies using various patient and control groups. This has enabled them to conclude that the pattern of masking deficits of schizophrenics differs from that of manic, depressed, and normal subjects (Saccuzzo & Braff, 1981). Moreover, this deficit has been demonstrated in remitted, process schizophrenics (Miller, Saccuzzo, & Braff, 1979); in paranoid schizophrenics (Braff & Saccuzzo, 1981); in both positive and negative subtyped schizophrenics (Braff, 1989; Weiner, Opler, Kay, Merriam & Papouchis, 1990); in non-medicated schizotypal patients (Balogh & Merritt, 1987; Braff, 1981); and in college students who had elevated schizophrenic-like MMPI scale scores, namely, the 278' code (Steronko & Woods, 1978). The composite interpretation of these findings is that poor-prognosis schizophrenics, in particular negative symptom patients (Braff, 1989; Green & Walker, 1984, 1986; Weiner et al., 1990), display deficits in the speed of information processing from the icon. This early visual deficit is independent of medication effects and gross pathology, and it is believed to be a stable trait marker of schizophrenia (Braff & Saccuzzo, 1985; Miller, Saccuzzo, & Braff, 1979).

Span of Apprehension. Span of apprehension determines how much information can be perceived simultaneously, literally in one glance. The span of apprehension procedure uses a brief, 50 to 100 ms, tachistoscopically presented stimulus array. The stimuli can be words, or more frequently, letters. Complexity is manipulated by increasing the number of additional elements. In the earlier versions of span of apprehension (i.e., whole-report technique of Sperling, 1960), subjects were asked to report as many stimuli as they could recall. Typically, schizophrenic and control subjects performed about equally, recalling about four or five items. However, using the partial-report technique of Sperling (1960), Knight, Sherer, and Shapiro (1977) found that poor prognosis and underinclusive schizophrenics performed more poorly than normal subjects, who could recall up to eight or nine items out of a 12 cell matrix. These early studies can be considered as attempts to measure basic capacity limitations in the sensory/perceptual domain on data-driven processing. The input duration is less than 100 ms. The sensory store lasts several hundred ms after the termination of a stimulus presentation but degrades over time.

The currently popular span-of-apprehension technique uses a modification of the Estes-Taylor (1964) forced-choice (i.e., signal detection) procedure which requires subjects to detect which of two target letters ("T" or "F") is presented on each trial. A given trial may contain 0 through 11 additional letters which can be arranged linearly or in matrix form. The basic finding is that with zero or few additional letters schizophrenics and controls perform comparably, but the performance of schizophrenics declines as a function of increasing irrelevant noise letters (Asarnow & MacCrimmon, 1981; Neale, 1971).

In his study of the perceptual span in schizophrenics, Neale (1971), using Estes' (1965) formulae, calculates the number of correct detections by schizophrenics and finds that they are accurate approximately 50 percent of the time. The Estes-Taylor (1964) version can be considered as less taxing of either capacity or memorial processes, and as reflective of conceptually-driven processing, because the expectation of either a "T" or "F" guides the search.

Recently, Asarnow and MacCrimmon and their colleagues conducted numerous investigations in schizophrenic and other psychiatric subgroups, using the span-of-apprehension measure. They found dysfunctions, specifically, reduced number of correct detections, in the following spectrum of individuals: (a) foster children at heightened genetic risk for schizophrenia (Asarnow & Sherman, 1984; Asarnow, Steffy, MacCrimmon, & Cleghorn, 1978); (b) in clinically remitted and asymptomatic schizophrenics (Asarnow & MacCrimmon, 1978); (c) in partially remitted schizophrenics but not in partially remitted manic-depressives (Asarnow & MacCrimmon, 1981); and (d) in individuals without psychiatric histories who had elevated scores on indices of schizotypy and on the schizophrenia scale of the MMPI (Asarnow, Neuchterlein, & Marder, 1983). Some highlights from their studies will be detailed here.

In their study of 12-year-old children, who met DSM-III (American Psychiatric Association, 1980) criteria for schizophrenia and were compared with mental-age matched controls and younger children, Asarnow and Sherman (1984) found that the schizophrenic children (like their adult counterparts) were equally efficient on a whole-report procedure, but displayed reduced spans on the partial-report technique. Asarnow and Sherman postulated that all the children utilized a serial information processing strategy, but the schizophrenics displayed inefficiencies in their controlled attentional processes.

In a study of schizophrenic and manic-depressed outpatients free from major symptomatology, who had maintained a stable community adjustment for a minimum of one year, Asarnow and MacCrimmon (1981) found significantly greater impairments in the schizophrenic group than in the manic-depressive group, who were intermediate between the schizophrenic and normal subjects. Both patient groups were on maintenance drugs appropriate to their diagnosis and clinically remitted status, and were tested during a periodic visit to the outpatient clinic. A closer look at the mean number of detections in the schizophrenic group reveals a bimodal distribution, indicating a subgroup of considerably poorer performers. An unexpected finding was that any attempt at correlating this subgroup's performance with traditional dimensions such as premorbid adjustment, chronicity, paranoid status, demographics, or current clinical state were uninformative. These converging findings have led Asarnow and colleagues to favor considering span of apprehension a trait vulnerability marker that is "likely indexing a schizophrenic diathesis rather than current (clinical) state" (Asarnow & MacCrimmon, 1981, p. 1010).

Strauss, Bohannon, Stephens, and Pauker (1984) investigated span of apprehension in schizophrenics, bipolar-manics, bipolar-depressives, and nonpsychotic patients and were unable to replicate the Asarnow and MacCrimmon (1981) findings. Strauss et al. found that their schizophrenic and manic groups did not differ significantly from each other, and the depressive group performed best. However, these discrepant findings may be due to several differences between the two studies. Some possible factors are that Strauss et al. studied inpatients who were more actively disturbed; Asarnow and MacCrimmon did not differentiate between bipolar-manic and bipolar-depressed; the clinical groups within each study were diagnosed via different classification systems; and, perhaps most importantly, the medication regime of the subgroups in the Strauss et al. study was not well controlled, and numerous subjects were taking both neuroleptics and lithium. Drug interaction effects on span of apprehension have been reported by Spohn, Lacoursiere, Thompson, and Coyne (1977) and Marder, Asarnow, and Van Putten (1984). Strauss et al. attempt to reconcile the disparity by suggesting that reduced span may be a marker of manics only during episodes of the disorder, but it may be present both during and between episodes in schizophrenics, reflecting a more persistent vulnerability in schizophrenia. This illustrates that the same apparent performance deficit may covary with psychiatric status in one case, and be independent of it in another.

It seems that the weight of the evidence supports consideration of span of apprehension as a vulnerability marker. Kietzman (1985) suggests that on the basis of a temporal processing framework, backward masking qualifies as a sensory vulnerability marker, while span of apprehension qualifies as a perceptual one because it taps processing beyond the first few hundred ms.

Perceptual Organization. Perceptual organization studies investigate whether and to what extent subjects utilize gestalt principles such as proximity, similarity, symmetry, closure and grouping to organize percepts. An early paper by Kaswan (1958) investigating the temporal sequence of spatial organization found that both medical-surgical and schizophrenic patients utilized proximity in an organizational task, but the schizophrenic patients required longer stimulus durations. Snyder, Rosenthal, and Taylor (1961) and Snyder (1961) investigated perceptual closure by asking their subjects to reproduce incomplete line drawings of simple figures. The normal subjects, as predicted, demonstrated closure (i.e., ignoring details such as gap size), but the chronic schizophrenic subjects failed to demonstrate closure, copying more precisely the line lengths and the size of the gaps.

Cox and Leventhal (1978), using a variety of tasks that required invoking the principles of grouping and segregation in the identification of the salient aspects of a stimulus, found that process schizophrenics performed more poorly than matched controls. However, under enhanced conditions, that is, when the salient aspects of the stimulus were made thicker and brighter, these same schizophrenic subjects performed comparably with controls.

In a complex task conducted by Frith, Stevens, Johnstone, Owens, and Crow (1983), subjects were asked to sort faces, nonsense objects, and histoforms into groups based on their common or random features. The features of the faces and nonsense objects could be integrated into a whole, whereas those of the histoforms could not. These investigators hypothesized that when non-random features were present, controls would sort faces better than histoforms because the former could be integrated (i.e., perceived holistically), allowing more features to be handled simultaneously. For the random feature condition, normal subjects would show greater impairment in the sorting of faces than for the histoforms because the presumed automatic tendency for face-integration would be disadvantageous. It was hypothesized that schizophrenic subjects have a tendency not to integrate; therefore, both faces and histoforms would be processed about equally with a comparable decrement in the presence of a random feature for both faces and histoforms. The results were as predicted, suggesting that for the schizophrenic subjects the integrated gestalt of the face was not dominant over its components.

These studies suggest an early-stage deficit in schizophrenic processing. Schizophrenic subjects appear either not to utilize gestalt organizing principles when integrating a stimulus (Frith et al., 1983; Snyder, 1961; Snyder et al., 1961); or they use them less efficiently (Cox & Leventhal, 1978; Kaswan, 1958). Rather, they seem to rely on analytic processing, focussing instead on the discrete elements of the stimuli. Typically, the schizophrenic subjects' use of an analytic mode of processing has been regarded as a deficit. However, several recent studies have found that under certain stimulus conditions this deficit results in better patient performance relative to controls. Place and Gilmore (1980) report on two studies investigating perceptual organization in schizophrenics and drug abusing controls. In both studies, the stimuli used were one to six vertical or horizontal lines displayed on the imaginary points of a hexagon. The subjects' task was to report the number of lines. In study one, lines appeared either by themselves (no noise condition) or with circles (noise condition). Schizophrenics performed comparably with controls in condition one, but more poorly in the noise condition. In study two, Place and Gilmore presented schizophrenics and controls with three stimuli conditions: (a) all lines of the same orientation (homogeneous condition), (b) lines in sets of alternating orientations (heterogeneous/adjacent condition), and (c) ungrouped lines of alternating orientations (heterogeneous/nonadjacent condition). While the performance of control subjects declined from condition (a) to (c) schizophrenics' performance remained relatively constant across all conditions. Place and Gilmore reported that the schizophrenic subjects' performance in the two studies demonstrates their deficit in perceptual organization. In the noise condition, schizophrenics performed poorly not because they were *distracted* by the irrelevant circles, but because they failed to partition the stimuli elements into those to be counted or not. In the second experiment, this failure to recognize and use the inherent grouping of the lines actually benefitted them, resulting in greater accuracy than controls in both heterogeneous conditions. Apparently, schizophrenics were not as influenced by the increasingly complex organizational aspects of the stimuli.

Wells and Leventhal (1984) replicated and extended Place and Gilmore's (1980) findings by testing paranoid and nonparanoid schizophrenics, nonschizophrenic patients, and controls. Subsequently, in an unpublished study, Wells and Leventhal (personal communication, 1986) used "X"s and "O"s in additions to lines and found the same results as Place and Gilmore (1980) and Wells and Leventhal (1984).

A recent study of perceptual organization (Orlowski, 1986; Orlowski, Kietzman, & Dornbush, 1987) used the same paradigm as Place and Gilmore (1980) but measured reaction time in addition to accuracy. Orlowski (1986, Orlowski et al., 1987) modified the task slightly by using horizontal and vertical bars instead of lines, displaying the stimuli on a computer screen rather than on a T-scope, and standardizing the stimulus presentation to 33 ms. Subjects were instructed to report the number of bars presented. The control subjects included young and elderly normal subjects. Under the more complex perceptual grouping conditions (i.e., heterogeneous/nonadjacent) and with increasing number of bars to count, the reaction time (RT) scores of the schizophrenic patients were faster than either control group. This result (a) paralleled the accuracy findings of Place and Gilmore (1980) and Wells and Leventhal (1984); (b) suggested that the quicker reaction time performance reflected a real schizophrenic processing deficit; and (c) argued against a generalized deficit (Chapman & Chapman, 1973) explanation.

Additional support for the specificity of the perceptual organization deficit to schizophrenia derives from a study by Silverstein, Raulin, Pristach and Pomerantz (1989). They assessed the perceptual organization ability of schizotypic psychosis-prone college students using visual stimuli wherein the configuration, number, and suffixes of the elements were manipulated to form good or poor perceptual groupings. These investigators hypothesized that the anhedonic schizotypic subgroup, in particular, would most likely resemble the poor premorbid, negative symptom subgroup of schizophrenics on these tasks. Their prediction was based on prior research which suggested that the heterogeneity in schizophrenia was also demonstrable in schizotypic individuals, and that anhedonics had displayed deficits similar to poor prognosis schizophrenics in some forms of backward masking (Balogh & Merritt, 1985), orienting, other attention and psychophysiological aspects of stimulus significance (Simons, 1982), and deviant psychological test results (Edell & Chapman, 1979). Silverstein et al. report their failure to demonstrate perceptual organization deficits in this group. These negative results are important because they circumscribe the deficit as specific to schizophrenics as opposed to schizophrenia-prone or schizophrenic-spectrum individuals. Collectively, these perceptual organization studies suggest that the superior performance of the schizophrenic subjects occurs because the patients are less reliant upon, or are less influenced by, gestalt organizational principles when processing visual displays.

The most recent pair of studies of perceptual organization in schizophrenia (Knight, Elliott, & Hershenson, 1991a, 1991b) tested the specificity of this deficit from a different angle. In study one, Knight et al. tested schizophrenics, affectives, and controls on a physical- and name-matching task presented in either symmetrical or asymmetrical forms. They reasoned that if schizophrenics were deficient in recognizing and using symmetry, this would indicate a very fundamental and pervasive deficit in perceptual organization and integration. Symmetry is considered a very early-developing organizational principle (Bornstein, Ferdinandsen, & Gross, 1981, cited in Knight et al., 1991, p. 15), and deficits at this level would suggest greater degree of impairment and implicate an earlier occurring stage of processing as the locus for the observed deficits. The results of this study clearly indicated that schizophrenics performed comparably to controls and did not support the presence of a deficit in perceiving symmetrical organization. Study two used a visual matching paradigm in which the *arrangement* (square or linear) of the stimuli was critical in determining whether subjects would use holistic or sequential processing. Though the configuration of the stimuli invoked the correct process in the affective, control, and good premorbid schizophrenic groups, the poor premorbids' pattern of responding did not vary in response to the square or linear presentations. These studies suggest that when a prepotent gestalt organizing aspect such as symmetry is present, schizophrenic subjects can use it. However, when required either to apply their own strategies or to use perceptual grouping, they are deficient.

Collectively, these perceptual organization studies demonstrate that schizophrenics have a specific early information processing deficit. Moreover, their perceptual and grouping deficit can actually benefit them in tasks requiring analytic processing, for example, the numerosity tasks (Orlowski, 1986; Place & Gilmore, 1980; Wells & Leventhal, 1984). Presumably the superior performance occurs because they are less influenced by, or are less attentive to, the inherent gestalt properties of a stimulus when processing visual displays.

Integration and Rationale for Current Research

The robust findings of specific deficits in the areas of backward masking, span of apprehension, and perceptual organization would be greatly enhanced if one could demonstrate how these deficits are interrelated and how they converge to elucidate the nature of these dysfunctions. The performance deficits of schizophrenics, particularly poor-prognosis schizophrenics, clearly implicate differences in their early visual information processing. However, their deficits could arise or be attributed to two alternate sources—deficiencies in the icon proper, or in the transfer of information from the icon to subsequent stages. Properties of the icon that might be deficient include its duration, capacity, or decay rates. Transfer dysfunctions could account for slowness of processing or for problems in transferring information from spatial to verbal encoding.

To test these competing hypotheses requires a task that dissociates these aspects from each other. Knight, Sherer, Putchat, and Carter (1978) adapted the successive-forms dot-integration task of Eriksen and Collins (1967), which the latter used to measure temporal visual integration in normals. Eriksen and Collins' procedure involves successive presentations of pairs of slides for which they varied ISI. Each slide alone appeared to be composed of random dots. However, when the complementary patterns were fused, an embedded syllable became apparent. They measured iconic duration by varying ISI. Knight and colleagues (1978) used pictures of common objects instead of syllables, and each individual slide seemed composed of random lines. A subsequent replication by Spaulding et al. (1980) which measured integration by increments of 5 ms intervals, exactly confirmed the earlier findings and found no differences in the icon decay rate between normals and schizophrenics.

These three studies confirming intact iconic function led Spaulding et al., (1980) to declare that one "could retire the hypothesis of a defective icon as important in schizophrenic cognition" (Spaulding et al., 1980, p. 642), and they suggested, instead, that post-iconic transfer processes were more likely to be compromised. There remained one inconsistency. While Knight and coworkers (1978) likewise found no differences between schizophrenics and controls on their integration tasks, Knight et al. found iconic durations in both groups to be considerably longer than the 100 ms reported by Eriksen and Collins (1965) and Spaulding and colleagues (1980).

The seeming inconsistency, together with evidence from other investigators studying normals' cognitive processes via various procedures (Kroll & Hershenson, 1980; Phillips, 1974; Potter, 1976) suggested that the traditional formulation of the icon as a large capacity, one second duration, veridical representation needed reformulation. Converging evidence suggested that the classical icon model (Neisser, 1967; Sperling, 1960) had confounded two processing stages: (a) a brief (100 ms) stage which consists of a large capacity veridical sensory trace of the stimulus input; and (b) a subsequent limited capacity, schematic abstractive store which persists for approximately another 600 ms. The latter stage, which Phillips (1974) called short-term visual memory (STVM), seems to provide a brief working span in which to begin the consolidation necessary for subsequent encoding (Potter, 1976), and also allows information to be processed sequentially rather than in parallel (Kroll & Hershenson, 1980).

Studies by Kroll and Hershenson (1980) and Rosen and Hershenson (1983) investigating processing of same-different judgments in normals provided insights regarding characteristics of the STVM store as well as the spark for investigating what the nature of the deficit in STVM might be. Based on the new formulations of the icon, Knight (1984) concluded that the discrepancy of the longer duration for his picture-integration task versus the Eriksen and Collins (1965) and Spaulding et al. (1980) dot-integration results could be resolved by considering the complexity of the stimuli themselves. He reasoned that the dot stimuli were so complex that they could only be encoded in the higher capacity sensory store and therefore decayed within a 100 ms. However, the pictures were easily encodable line drawings that could be partially abstracted and encoded in the more schematic STVM and hence resulted in longer durations.

Additional confirmation for the existence of two iconic processes can be inferred from Long's (1980) investigation of normal cognition. He drew a distinction between the energy and persistence effects which are affected by physical characteristics of the stimulus such as duration or intensity, and the memory effects which are reflections of the amount and type of information that is processed. Following Long (1980), Magaro and co-workers (Magaro, Johnson, & Boring, 1986; Magaro & Page, 1982) differentiated between duration or strength of the icon and processing or transferring of the information. They subdivided the iconic stage into a sensory stage and a secondary perceptual stage which involves encoding processes. Automatic or controlled processing, and tasks such as span of apprehension, are subsumed in these encoding processes. In investigations of schizophrenics (subtyped into paranoid-nonparanoid, good and poor premorbids) and controls, Magaro and Page (1982) confirmed intact iconic functioning in all groups. They found no differences in the strength or duration of the icon between the schizophrenics and controls, suggesting that the deficit resided in the encoding processes, which is temporally similar to Phillips' (1974) STVM stage.

Given the weight of the evidence supporting an intact icon in schizophrenics, investigations to determine the nature of the interference in STVM seemed appropriate. To evaluate processing within the STVM range (i.e., within the first 600-1000 ms), Knight, Elliott, and Freedman (1985) modified the traditional backward masking technique. Essentially, they varied the nature of the mask so that there was either a noise mask, a patterned but meaningless mask, or a cognitive (i.e., informational) mask. They tested good and poor premorbid schizophrenics, nonschizophrenic psychotics, and normals. Knight et al. used backward masking to measure stimulus-onset-asynchrony (SOA; the interval between onset of the stimulus to onset of the mask) instead of ISI. They found that at 200-300 ms SOAs only the poor premorbids processed the patterned mask as meaningful and treated it as the cognitive mask.

The STVM models of normal processing (Kroll & Hershenson, 1980; Phillips, 1974; Potter, 1976) suggest that a pattern mask should be disruptive at short intervals, while iconic representation and storage are operative, but not at ISIs or SOAs beyond 200-300 ms. A cognitive mask, however, ought to be disruptive both at short and long intervals, because it requires processing of information. The failure of poor, but not good, premorbids to discriminate between mask types at longer SOAs, strongly suggest that they processed the pattern mask as if it were meaningful. Knight et al. (1985) hypothesize that the STVM deficits reflect a failure to discriminate between visual and cognitive information, that is, a failure to perceptually segregate meaningful from meaningless information.

Braff (1981) and Saccuzzo and Braff (1981) posit that the backward-masking procedure is a sensitive measure of speed of encoding. They interpret the STVM deficits as indicative of slow processing. In addition, they report that a subset of schizophrenics, those with predominantly negative symptoms, require longer stimulus presentations

(Braff,1989; Weiner et al., 1990). The suggestion is that these individuals, and perhaps paranoid schizophrenics as well (Braff & Saccuzzo, 1981), have a dual-factor deficit: an input sensory dysfunction requiring longer critical stimulus durations (CSD) and a slower speed of processing. The principal investigators of backward masking (Braff & Saccuzzo, 1981, 1985; Saccuzzo & Braff, 1981) have been faulted because they need to invoke two separate hypotheses to explain various aspects of their backward masking findings. While in agreement with their slowness-of-processing interpretation, investigators like Knight (1984; Knight et al., 1985), Magaro and Page (1982), and Kietzman (personal communication, 1987) take issue with the method for establishing individual CSDs and the explanation that it reflects impaired sensory registration.

The formulations of Saccuzzo and Braff and their colleagues are useful even when they do not fully coincide with Knight and colleagues' (1985) formulation. Firstly, they have provided an important specific temporal referent for the backward-masking encoding deficit—it occurs at ISIs greater than 60 ms and less than 500 ms. Below this range no one gets it right (performance is at chance levels), and in the 500-700 ms range, performance by schizophrenics and controls begin to converge and significant differences disappear. The 500-700 ms range coincides directly with the estimates of STVM in normals (Kroll & Hershenson, 1980; Phillips, 1974; Potter, 1976). This time-frame defines not only a stage of processing, but potentially a neuroanatomical substrate (Braff & Saccuzzo, 1985). Secondly, by specifying an alternative two-factor deficit model (Braff & Saccuzzo, 1985; Saccuzzo & Braff, 1981), they provide additional, testable models within the information processing framework. This can only serve to further elucidate the nature of the early visual processing deficit in schizophrenics.

To recapitulate, the three paradigms are interrelated in the following way. Knight (1984, in press-a, in press-b) and Knight and colleagues (1985, 1991a, 1991b) suggest that span of apprehension and backward masking studies reflect an early information deficit which seems to converge on the STVM stage of processing as the locus for the deficit. Perceptual organization deficits may provide a parsimonious explanatory mechanism for the failure of schizophrenics to discriminate (disembed) a masking stimulus from its target, or the failure to use grouping and chunking to correctly and quickly detect a "T" or "F" in the face of multiple distractor elements in the span of apprehension studies. The perceptual organization numerosity studies (Orlowski, 1986; Place & Gilmore, 1980; Wells & Leventhal, 1984) suggest the hypothesis that schizophrenics tend to disregard or to be less influenced by the inherent organizational aspects of stimuli. The thrice-replicated finding of superior performance by schizophrenics, relative to controls, on these types of tasks, yields two potent consequences—rebuttal of the oft-cited generalized deficit hypothesis (Chapman & Chapman, 1973) regarding schizophrenics differential performance; but perhaps more importantly it suggests the underlying mechanism(s) or processes that schizophrenics utilize when processing visual information.

Following the lead of Knight (1984, 1987, in press-a) and colleagues (Knight, Elliott & Hershenson, 1991a, 1991b), who have argued persuasively that real progress in understanding the nature of attentional dysfunction in schizophrenia will only come by examining task performance differences in a process-oriented, theory-driven approach, an investigation of the putative mechanisms or strategies underlying the superior performance on the numerosity tasks appeared warranted.

Of the three paradigms detailed herein, perceptual organization research was deemed most likely to continue to provide new or additional information regarding schizophrenics' early information attentional deficits. The reasons for this are severalfold. Both backward masking and span of apprehension have been investigated rather thoroughly and productively already. Though additional studies in these areas are useful in, for example, clarifying the link between these deficits and newer diagnostic subtyping such as predominantly positive, mixed or negative symptom clusters (Kay & Opler, 1987; Weiner et al., 1990), it would conceivably be more useful to attempt replication and extensions of the few, but significant studies of the perceptual organization deficit. Methodologically, perceptual organization studies have provided a serious challenge to competing alternative interpretations: in particular, the generalized deficit hypothesis (Chapman & Chapman, 1973). This hypothesis seeks to explain the poor performance of schizophrenics on virtually all tasks as arising from motivational or attentional factors which are not experimentally manipulated. Thus, the finding of performance differences between schizophrenics and controls is by itself not very informative because it fails to be instructive regarding the fundamental nature of the disorder. Numerous experiments, all putatively investigating attentional deficit, show little correlation among themselves, increasing the likelihood that competing interpretations may reflect artifactual, psychometric findings rather than real differences underlying performance between the groups.

Therefore studies that rebut this position are a valuable source for uncovering the true nature of the processing deficits of schizophrenic patients.

A solution is to include tasks or control subjects that would allow for an unambiguous interpretation of performance results. One example of this strategy was adopted by Orlowski, Kietzman, and Dornbush (1987) and Miller, Saccuzzo and Braff (1979) in which they used elderly normals as controls. An alternate strategy is to develop tasks on which schizophrenics do better—clearly this is contraindicated from the generalized deficit hypothesis—and to elucidate what contributes to their performance under these conditions. An example of this strategy is found in the improved numerosity performance of schizophrenics in studies by Place and Gilmore (1980), Wells and Leventhal (1984), Orlowski (1986), and Orlowski, Kietzman, and Dornbush (1987).

Studies of perceptual organization could be enhanced if they were designed within an information processing framework. Information processing approaches provide tools and methodologies that paradoxically allow for both the specification and the integration of the nature of the processing deficit in schizophrenia. The harnessing of the methodology and empirical base of the information processing approach to relevant clinical concerns serves a twofold function. Firstly, theories of cognitive psychology can benefit investigations of psychopathology by drawing on the large databases accumulated on normals' cognitive functioning. Secondly, the strength of this model lies in its ability to specify precisely under what stimulus conditions and where along the processing continuum the psychiatric patients' deficits lie. Thus, information processing models hold a key to informing us regarding normal human cognition, and disordered sensing, perceiving and thinking as well.

To understand impairments of visual processing in psychiatric populations, it is necessary to consider the manner in which normal control subjects process visual stimuli. One view, espoused by numerous investigators (Banks & Prinzmetal, 1976; Kroll & Hershenson, 1980; Mikitish, 1985; Navon, 1977; Phillips, 1974; Potter, 1976; Rosen & Hershenson, 1983), has argued that in normal visual processing there is first a predominance of global analysis followed by an analysis of the local details or elements. This global analysis is accomplished by gestalt laws of proximity, similarity, and good continuation, among others. By comparison, studies investigating visual processes in patients (e.g., Cox & Leventhal, 1978; Kaswan, 1958; Knight, Elliott, & Hershenson, 1991a, 1991b; Orlowski, 1986; Place & Gilmore, 1980; Snyder, Rosenthal & Taylor, 1961; Wells & Leventhal, 1984) suggest that schizophrenic patients are deficient in utilizing gestalt principles, thereby tending to bypass or to disregard the initial level of holistic processing and seeming, instead, to automatically process just the discrete elements of a stimulus.

Studies attempting to demonstrate differences between psychiatric patients and control subjects on visual perception tasks have almost unanimously found that the patients perform worse; for example, they may be less accurate or slower than controls. The schizophrenics' perceptual organization deficits are, however, not absolute. They can be modified by training or by increasing the salience of gestalt properties in a stimulus (Cox & Leventhal, 1978), and were not demonstrated in a physical- or name-matching symmetry task (Knight, Elliott & Hershenson (1991a). This suggests that: (a) schizophrenics do not have a pervasive perceptual organization deficit; (b) rudimentary forms of organizing a percept are available to them; and (c) new or additional tasks are required to tease apart the specific nature of their early information processing deficit.

Within the past decade, several studies investigating perceptual organization (e. g., Orlowski, 1986; Place & Gilmore, 1980; Wells & Leventhal, 1984), have reported the unusual result that under certain stimulus conditions schizophrenic patients' performance is superior rather than worse relative to that of control subjects. A careful reading of these studies yields the following: (a) all of the studies have involved the counting of elements in a stimulus array; (b) schizophrenics do not perform better across all conditions; (c) the performance of the patients does not vary appreciably in response to different stimulus configurations, whereas for the controls it does.

The composite interpretation of these studies is that tasks that simply require counting or feature analysis can result in better performance by schizophrenic subjects due to their presumed deficit in perceptual organization. Specifically, these studies suggest that the superior performance of schizophrenic patients reflects their lesser reliance upon gestalt organizational principles when processing visual displays. Moreover, these studies further suggest the hypothesis that normal controls and schizophrenics differ in their automatic modes of processing when viewing visual displays. Specifically, controls engage in a two-stage approach—a global analysis followed by a detailed one. Schizophrenics, on the other hand, tend either to bypass or to be deficient in applying the first stage—holistic analysis, when apprehending a visual stimulus; rather they move directly to the latter stage of processing and may outperform controls when it is advantageous to engage only in analytic processing.

To date, no one has actually tested the validity of the inferences from the prior numerosity studies. In particular, a sine qua non, requires testing the inference that schizophrenics use only one type of process. Do they not have global processing ability or capacity? Or do they use this mode of processing less efficiently? Is the putative two stage sequence (global followed by analytic) used by normals absent or deficient in schizophrenia? If the latter is the case, is this then a reflection of processes and strategies that are either less well learned, less automatic or harder to retrieve and invoke, as opposed to processes that function more automatically in controls? What are the temporal referents associated with these modes of processing?

In addition, several other concerns emerged with regard to the above cited studies. The numerosity perceptual organization studies had thrice been replicated using the same paradigm. This limited the generalizability of the reported findings. It was deemed desirable to ascertain whether schizophrenics' superior counting skills extended beyond that of just (counting) lines. In addition, new research needed to attend to other studies investigating perceptual organization deficits, and to incorporate and account for their findings. Several researchers had provided important information regarding the conditions and parameters that affect this processing deficit. Cox and Leventhal (1978) demonstrated that additional training, and increasing the salience of the groupings, enhanced performance. Knight and co-investigators (1991a) found that symmetry, presumably a more fundamental, early developing structure, was relatively intact even in the poor premorbid schizophrenics. The symmetry study of Knight et al. (1991a) is significant because it delimits the failure of perceptual processing to the holistic—developmentally, a later-occurring, and less automatized, gestalt organizing principle. Because these studies circumscribe the nature and specificity of the patients' attentional deficits, they are very important. New studies need to continue to amplify and refine the extent of schizophrenics' perceptual organization deficit. An additional drawback of all the studies in this area with the single exception of the Knight et al. (1991a, 1991b) studies, is that the only patient group to be compared with controls were schizophrenics. This does not allow one to determine whether the reported deficits are specific to schizophrenia or reflect psychoses more generally. One needs to incorporate other psychotic groups in studies of perceptual organization processing in order to determine the ways in which they both resemble and are dissimilar to schizophrenics.

The research reported herein serves, to this author's knowledge, as the first direct test of the hypothesis that schizophrenic, non-schizophrenic psychotic, and control subjects engage in different processing strategies when viewing visual perceptual displays. To date, relevant studies have only used a counting task. However, if tasks were designed that incorporated and required both analytic and holistic processing, then it would be possible to clarify whether the reported enhanced numerosity performance of schizophrenic patients is attributable to their greater reliance on analytic processing. To determine how specific this deficit is to schizophrenia, two non-schizophrenic psychotic and two normal control groups were tested and compared as well.

The purpose of this research, developed within the information processing framework, sought to address the concerns, limitations, and potentially very potent inferences of the perceptual organization studies in several ways. Strategies included: (a) designing tasks wherein the *same* stimuli were both in a counting task (which requires analytic processing), as well as in a form discrimination task (which requires holistic processing); (b) incorporating auditory cues at different delay values relative to the stimulus presentation, to allow for measures of temporal processing associated with the putative different modes of processing; and (c) testing of other psychotic (but non-schizophrenic) groups to ascertain whether this perceptual deficit is specific to schizophrenia or reflects psychoses and extreme psychopathology more generally.

Aims. The specific aims of this project were:

(a) to examine and compare schizophrenic, non-schizophrenic psychotic, and normal subjects on visual performance tasks involving early stages of information processing. Specifically, two perceptual discrimination tasks were compared; namely, (1) counting a varying number of elements comprising a stimulus pattern, and (2) the identification of different shaped stimulus patterns made up of varying number of dots;

(b) to gain an understanding of the holistic and/or analytic modes of processing that characterize schizophrenic, nonschizophrenic psychotic, and normal subjects;

(c) to measure, for each subject group, the stimulus conditions that facilitated the utilization either of (an) automatic processing strategy, or the transition to (a) lesser automatic processing mode (i.e., for normals the transition from holistic to analytic processing, and the reverse for schizophrenics);

(d) to use refined experimental techniques and methods to allow for the least ambiguous interpretation of the results by controlling for various potential sources of confounding that characterized some earlier research; and

(e) to provide groundwork for subsequent studies, wherein the hypothesized specific perceptual deficit can be studied as a potential episode or vulnerability marker; or as a way of differentiating schizophrenia from other psychotic disorders.

RESEARCH DESIGN

Subjects were tested on two perceptual tasks involving dot stimuli: a numerosity (number counting) task and a form-identification task. Performance was evaluated, as in Orlowski (1986), using two response measures: response accuracy and reaction time.

In addition to the manipulation of either the *number* of elements or the *shape* of the dot elements, a cuing tone was presented at 0, 2, or 4 s after the stimulus offset. This tone informed the subjects when to respond. Variable time delays between the stimulus offset and the cue to respond were designed to clarify the nature of information processing differences between schizophrenic, non-schizophrenic psychotic, and control subjects. Specifically, the imposition of a cue delay was intended to measure, for each subject group, the temporal sequence associated with the transition from holistic to analytic, or conversely, analytic to holistic processing modes.

Additionally, the tone delays were expected to improve upon the accuracy and reaction time findings obtained in prior studies, by avoiding possible confounds of those studies. Instructing subjects to respond only after the cuing tone had been presented, controlled the duration of delay before a subject was permitted to respond. It was hoped that this manipulation would effectively tease apart the response variables of speed and accuracy. In general, longer delays were regarded as implicitly enhancing accuracy by allowing more time for processing. At the 0 s delay, accuracy was considered secondary to speed, because subjects had relatively little time for processing, providing a comparatively pure reaction time measure. In general, this procedure strove to avoid the potential for ambiguity and "subject option" in the interpretation of instructions, by informing subjects that only responses that occurred after the tone were (to be) recorded.

Methods

Subjects. Six groups of subjects were tested in this study. A total of 79 subjects participated in all phases of the experiment and were retained in all analyses. The first two groups comprised of 24 schizophrenic patients, were subdivided on the basis of chronicity, yielding 8 acute schizophrenics (SA) and 16 chronic schizophrenics (SC). The criteria for determining chronicity were two-fold. The measures used, were (actual) number of prior hospitalizations (0 through 9), and previous psychiatric history (never had an episode, current episode of less than two years duration, current or successive episodes of greater than two years duration). These measures were very highly correlated and resulted in exactly a two to one split, with 16 chronic schizophrenics and 8 acute schizophrenics. The next two groups consisted of 17 psychotic patients who met criteria for a psychotic disorder other than schizophrenia. These patients constituted an affective psychotic group. This latter patient group was likewise split into two groups. Of these 17 patients, seven were diagnosed as bipolar, and all were in a manic phase. Six of the seven patients met criteria for an acute illness. These 7 patients constituted the bipolar (PB) psychotic group. Of the remaining ten non-bipolar (PN) psychotics, seven were diagnosed as schizoaffective; two as psychotic depression and one as psychotic NOS (not otherwise specified). All psychotics in the latter group met criteria for a chronic illness, thus replicating the 2:1 split seen in the schizophrenics. The latter two groups were control subjects. A total of 38 adults, composed of 22 Brooklyn College (C1) students, and 16 hospital staff (C2) subjects were tested. Beyond the 79 subjects included in all analyses, a small number of subjects were dropped either during testing due to their inability to complete testing (despite additional training), or excluded from analysis because it was determined that their primary diagnostic status was confounded either by significant drug history or an Axis-II (personality) disorder. Demographic data are displayed in Table 1.

All subjects participated voluntarily in this study. A detailed proposal of the design, purpose and benefits/risks involved was submitted to and approved by the Institutional Review Boards (IRBs) of both New York State Psychiatric Institute (NYSPI) and Columbia Presbyterian Medical Center (CPMC) as well as the ethics committee at Brooklyn College (BC). Detailed consent (i.e., recruitment) forms which describe the study, risks, and rights (confidential and otherwise) of patients and controls were submitted to and approved by the appropriate review boards. Copies of the approved patient and control consent forms appear in Appendix A.

The nature of compensation for participation was dependent on the policies and requirements of the recruitment sites. In general, patients were paid $10.00 upon completion of testing, C1 controls were not compensated monetarily, because their participation counted toward class requirements, and C2 controls were paid $10.00 per hour of participation, generally earning $20.00 to $25.00. Seven patients participated without compensation, since these patients were part of an umbrella research protocol. All participants were informed in advance as to the nature of compensation and were free to

Table 1

Demographic Characteristics by Group and Gender

Variable	Groups					
	Schizophrenics		Other Psychotics		Controls	
	SA	SC	PN	PB	C1	C2
			Males			
Age						
M	22.0	27.8	35.2	26.4	39.0	34.7
SD	2.0	4.8	11.4	5.5	14.1	5.5
n	5	9	5	5	2	6
Race						
White	2	6	3	3	2	5
Black	1	2	1	1	0	1
Hispanic	1	1	1	1	0	0
Other	1	0	0	0	0	0

(table continues)

Table 1 (continued)

Variable	Schizophrenics		Other Psychotics		Controls	
	SA	SC	PN	PB	C1	C2
			Males			
Marital Status						
Never Married	5	8	4	3	1	3
Ever Married, Childless	0	0	1	0	0	2
Parent (single or married)	0	1	0	2	1	1
Educational Level						
M	13.1	12.9	14.0	14.3	14.0	16.6
SD	1.6	1.9	2.4	1.4	2.1	2.0
n	5	9	5	5	2	6

(table continues)

Table 1 (continued)

Variable	Groups					
	Schizophrenics		Other Psychotics		Controls	
	SA	SC	PN	PB	C1	C2
			Males			
Psychiatric History						
None	0	0	0	0	0	6
Acute	5	0	1	3	0	0
Axis II	0	0	0	0	1	0
Chronic	0	9	4	2	0	0
Trauma	0	0	0	0	1	0
Medical Status						
Not on Medication	1	2	1	1	1	6
On Medication	4	7	4	4	1	0

(table continues)

Table 1 (continued)

Variable	Schizophrenics		Other Psychotics		Controls	
	SA	SC	PN	PB	C1	C2
			Males			
N Hospitalizations						
0	3	1	1	3	2	6
1	2	1	1	1	0	0
2	0	2	1	0	0	0
3	0	2	0	0	0	0
4-5	0	1	0	0	0	0
6-8	0	1	1	0	0	0
9+	0	1	1	0	0	0

Groups spans all six group columns.

(table continues)

Table 1 (continued)

Variable	Schizophrenics		Other Psychotics		Controls	
	SA	SC	PN	PB	C1	C2
			Females			
Age						
M	31.3	32.3	35.4	39.0	31.0	30.9
SD	9.6	6.7	6.8	11.3	11.4	9.3
n	3	7	5	2	20	10
Race						
White	2	3	3	0	10	7
Black	1	4	0	1	7	2
Hispanic	0	0	2	1	0	1
Other	0	0	0	0	3	0

(table continues)

Table 1 (continued)

Variable	Groups					
	Schizophrenics		Other Psychotics		Controls	
	SA	SC	PN	PB	C1	C2
			Females			
Marital Status						
Never Married	1	6	3	0	10	5
Ever Married, Childless	0	0	0	1	1	2
Parent (single or married)	2	1	2	1	9	3
Educational Level						
M	14.2	11.4	13.5	12.8	14.6	15.1
SD	2.0	2.9	2.3	1.1	1.5	2.5
n	3	7	5	2	20	10

(table continues)

Table 1 (continued)

Variable	Groups					
	Schizophrenics		Other Psychotics		Controls	
	SA	SC	PN	PB	C1	C2
			Females			
Psychiatric History						
None	0	0	0	0	20	8
Acute	3	0	1	1	0	1
Axis II	0	0	0	0	0	1
Chronic	0	7	4	1	0	0
Trauma	0	0	0	0	0	0
Medical Status						
Not on Medication	1	3	1	0	19	10
On Medication	2	4	4	2	1	0

(table continues)

Table 1 (continued)

Variable	Groups					
	Schizophrenics		Other Psychotics		Controls	
	SA	SC	PN	PB	C1	C2
	Females					
N Hospitalizations						
0	2	0	1	1	20	10
1	1	1	1	1	0	0
2	0	2	1	0	0	0
3	0	0	0	0	0	0
4-5	0	2	0	0	0	0
6-8	0	0	0	0	0	0
9+	0	2	2	0	0	0

Note. SA = acute schizophrenics, SC = chronic schizophrenics, PN = non-bipolar non-schizophrenic psychotics, PB = bipolar non-schizophrenic psychotics, C1 = BC controls, C2 = non-BC controls.

withdraw at any time without penalty or risk of affecting their treatment.

The two patient groups were obtained from three separate inpatient units, each with a somewhat different orientation. A majority (*n* = 29) of the patients were recruited from the clinical/research, mostly acute, inpatient unit at the Neurological Institute (NI) at CPMC, seven additional patients were recruited from a recently-opened inpatient unit specifically geared as a schizophrenia research unit (SRU) at NYSPI, and five more patients were obtained from an inpatient community service clinical unit serving severely ill, mostly chronic patients. The first two units encouraged research along with clinical care, but the latter unit had fewer suitable subjects due to the patients chronicity, dual-diagnoses, and language difficulties.

Control C1 subjects were undergraduates who were obtained via recruitment postings in the BC Psychology department. The hospital controls were obtained via notices posted in the "subjects wanted" areas at NYSPI and CPMC and through personal communication with staff members of the inpatient units.

The inclusionary criteria for patients were: (a) 18 years of age or older, (b) English speaking, and (c) a DSM-III-R (1987) Axis-I diagnosis. Exclusionary criteria were no current (i.e., past year) substance abuse, and no organic or medical disorder. Inclusionary and exclusionary criteria for controls were the same as for patients, save one major difference. Controls had to be free of any Axis-I diagnosis for a minimum of five years. Two control subjects met criteria for a (non-psychotic) personality disorder, and two more individuals were suspected of having experienced a moderate to severe depression several years previously.

All subjects included in this study were interviewed using the Structured Clinical Interview for DSM-III-R patient (SCID-P) and non-patient (SCID-NP) versions (Spitzer, Williams, Gibbon, & First, 1988). Non-patients were additionally screened using SCID-II (Spitzer et al., 1988) which tests for any DSM-III-R personality disorder. A subset of patients were also rated by the Positive and Negative Syndrome Scale (PANSS) developed by Kay and Opler, 1987, to subtype schizophrenic subjects by their predominant features.

Subjects' medication status was monitored both prior to and at the time of testing. To the extent that it did not interfere with the patients' clinical management, all patients, within each group, were maintained on similar drug regimes.

Stimuli. Each stimulus was one of three visually presented shapes (square, rectangle, or rhombus) made up either of four, five, or six dots. For each shape there was always, at a minimum, one dot in three of the four corners (i.e., at least three corners were defined) and there were a maximum of four possible positions for dots on each side. Examples of the stimuli used in this study are included in Appendix B.

The actual stimuli used in this research were selected as follows by a computer program. Ninety unique stimuli patterns, based on the nine possible stimuli types, (configured by the three levels of numbers of dots × the three levels of shape), were randomly generated. Each of these 90 stimuli patterns were paired with the three levels of delay (0, 2, or 4 s) creating a file of $90 \times 3 = 270$ stimuli. The program randomly selected a stimulus pattern and noted its delay value. Twenty-nine additional stimuli were randomly selected with the one restriction that they be of the same delay value as the first (already selected) stimulus. These 30 stimuli constituted the first block. Five additional blocks were likewise created with the further restriction that no more than two blocks have the same delay value. Each complete run allowed for two presentations of the original 90 stimuli, at two different delay values. This procedure resulted in six blocks of 30 presentation trials apiece, for a total of 180 trials per condition. The precise sequence of trials was maintained for all subjects and for both task conditions.

Hardware. The stimuli were presented by using an IBM PS/2 Model 50 as a tachistoscope. The microcomputer was used in all phases of experimentation, namely, for stimulus generation and presentation, experimental control of all timing variables, data storage, and analysis.

Procedure

General. There were two task conditions in this experiment. All subjects made both numerosity judgments and form judgments. For the number condition, subjects were asked to report whether there were four, five, or six dots. For the form condition, subjects were asked to report which of the three geometric forms had been presented.

In addition to the manipulation of number versus form, on each trial the stimulus display was followed by a tone at delays of 0, 2, or 4 s. Subjects were instructed to respond only after they heard the tone. Within a given condition, each stimulus trial was randomly paired with two of the three cue delays. Thus, a complete set of trials for each condition was composed of 180 trials, allowing for the comparison of the effects of the delay manipulation both within and across conditions. The instructions for the practice sessions and for each condition are listed in Appendix C.

Training. Testing for each condition was preceded by training relevant to that condition. The purpose of the training sessions was to familiarize subjects with the test conditions, the types of stimuli, and to ensure that subjects could do the task. The practice stimuli were representative of those used in the main experiment, differing from the experimental/test stimuli only in the relative positions of the dots making up the shapes.

Training for the number condition consisted of familiarizing the subjects with the experimental setting. This included showing them practice stimuli and pointing out to them "this is an example of a four (or five, or six) dot (point) stimulus," alerting them to the differences between the ready signal and the auditory cue which signalled when they may respond, and demonstrating the computer keys they were to use.

Training for the form condition included two parts: demonstrations of the three shape prototypes indicating all (i.e., 12) possible dot locations, as well as demonstrations of experimental (i.e., 4-6 dot) stimulus examples. The defining characteristics of the prototypes were described several times to ensure that all subjects were able to identify them. This was especially important for the patients to assure their familiarity with the names of the shapes and their appearances. When necessary, subjects were shown up to 25 practice trials before testing began.

Testing. All trials were initiated with an auditory warning (Ready) tone generated by the computer. A fixation point appeared on the screen simultaneously with the onset of the warning tone. The offset of the fixation point was followed by the stimulus which was presented for 100 ms. A cuing tone of a pitch different from the warning signal occurred at either 0, 2, or 4 s following the stimulus offset. Subjects depressed one of a set of three pre-selected and task-specific labelled computer keys (i.e., either the 4, 5, or 6 key, for the number condition; or analogously, the square, rectangle, or rhombus key, for the form condition) activating the clock that measured reaction time in ms. Short breaks of approximately one to two minutes were given after three blocks of trials (i.e., 90 trials) and there was a five-to-ten minute break between task conditions.

Hypotheses

The main goals of this research were:

(a) to ascertain whether the discrimination of form differs from that of number;

(b) to ascertain whether there are reliable group differences associated with different modes of processing, and to examine further whether these group differences are specific to schizophrenia or reflect extreme psychopathology more generally;

(c) to ascertain the temporal sequence associated with each mode of processing; and

(d) to ascertain which shape, if any, serves as a better gestalt; and to determine the factors that contribute to this effect.

The hypotheses that were derived from these stated goals were as follows.

(a) It was expected that the processing of form differed from the processing of number. Specifically, form discrimination requires invoking holistic processing, while number discrimination involves analytic processing.

(b) Group differences were expected with respect to the modes of processing required for the two tasks. Moreover, it was specifically expected that being ill with schizophrenia, as opposed to having another psychotic disorder, or no psychiatric disorder, impeded one's performance on tasks requiring perceptual organization and holistic processing differently than on analytically-oriented tasks.

(c) Given the evidence supporting the two-process model detailed above (Kroll & Hershenson, 1980; Loftus et al., 1988; Mikitish, 1985; Navon, 1977; Phillips, 1974; Potter, 1976), it was expected that the processing of form takes precedence over the processing of number. However, this temporal sequence seemed particularly true for normals, and less likely to obtain for schizophrenics. It was furthermore expected that the optimal processing mode could be used by all subject groups, but that the time frame associated with the transfer from their automatic to less automatic processing strategies differed.

(d) There were no clear-cut predictions with respect to whether a particular shape was easier to discriminate than another, nor whether group differences would emerge with regard to shape. However, classical gestalt theory implies that good gestalts should be more discriminable than poor gestalts, resulting (presumably) in faster and more accurate responses. Furthermore, it appeared likely that irrespective of shape, the number of dots which are used to configure a shape may discriminate the groups. For example, for the form condition, a six-dot shape may be easier to apprehend than a four-dot one, differentially affecting schizophrenics who might benefit more from additional gestalt cues.

(e) In addition, when shape is a latent cue, as in the number task condition, two empirically-driven possibilities emerge with respect to the relationship between increasing number of dots and group membership. These are:

(1) Schizophrenics perform the same regardless of the number of dots in the number condition, while controls do worse with increasing number of dots (Place & Gilmore, 1980; Wells & Leventhal, 1984).

(2) Schizophrenics perform worse with increasing number of dots in the number condition, while normal controls perform the same across all levels of dots (Asarnow & MacCrimmon, 1981).

Design and Data Analysis

The data were analyzed by a $6 \times 2 \times 3 \times 3 \times 3$ repeated measures ANOVA, calculated using BMDP4V (Davidson & Toporek, 1988). These factors were, respectively, named G (for Group), C (for Condition), P (for number of Points), S (for types of Shape), and D (for Delay). The experimental design for this study involved a between--groups factor (G) with six levels: acute schizophrenic (SA), chronic schizophrenic (SC), non-bipolar psychotic (PN), bipolar psychotic (PB), BC control (C1), and non-BC control (C2); and four repeated measures within-group factors (C, P, S, and D). The levels for these factors were as follows: (a) two levels of task condition—number and form; (b) three levels of points—four, five, and six dots; (c) three levels of shape—square, rectangle, and rhombus; and (d) three levels of delay—0, 2, and 4 s.

To guard against the possible violation of compound symmetry assumptions which arise in a repeated measures ANOVA analysis, all reported univariate results in this design use the Huynh-Feldt adjustment.

Two response measures were obtained on each trial—reaction time (RT) and accuracy. RT was measured in ms for up to a maximum of 3000 ms elapsed time; accuracy was coded as correct (1) or incorrect (0). If the maximum time had elapsed, RT was coded as -1 and recorded as missed, while accuracy was scored as 0. At the end of each block of 30 trials, all missed trials (for that block) were repeated once with the original figure reversed right to left.

For each of the $2 \times 3 \times 3 \times 3$ within-subject cells, RT and accuracy means were calculated. Each cell represented a particular composite of the varying levels of the factors. RT and accuracy means, per cell, were derived by combining the responses to the first presentation of the stimulus with those generated by the substituted trials in lieu of the missed ones. Only one repetition per missed trial was permitted. Thus, every cell score reflected a mean RT and mean accuracy score which was derived by summing and averaging the relevant presentation (i.e., trial) scores for all individuals within each group. A table of presentation frequencies of the within-subject cells appears in Appendix D.

The following a priori tests and comparisons were planned:

(a) The first hypothesis was evaluated by the (C-1) main effect, comparing the marginal mean for the number condition with the marginal mean for the form condition.

(b) The second hypothesis implied a G × C interaction which was evaluated by examining the simple effects of condition at each level of group. In addition, the G × C interaction was further partitioned into non-orthogonal condition by group contrasts. Contrast one: schizophrenics compared with non-schizophrenic psychotics; contrast two: schizophrenics compared with the two normal control groups combined; contrast three: non-schizophrenic psychotics compared with the two normal control groups combined; contrast four: all four patient groups compared with the two normal control groups combined. The predictions were as follows: (1) schizophrenics should do better on the number task than on the form task, and (2) normals should do better on the form task than on the number task.

(c) The third hypothesis was evaluated by the C × D × G 3-way interaction, and by examining the simple C × D interaction at each level of group, and by inspecting the simple, simple delay at specific task for specific group. The expectations were as follows: There should be no effect of delay for the form condition for normal subjects, and a positive effect of delay (greater accuracy or shorter RT) for the number condition for normal subjects. Conversely, there should be a positive effect of delay (greater accuracy or shorter RT) with increasing delay for the form condition for schizophrenic subjects. No change across delays or alternatively a dip in performance at the longest delay for the number condition for the schizophrenics was expected. The prediction for the other psychotic group was less certain, and their inclusion in the study was intended to shed light on the way in which their processing was both similar to and different from schizophrenic and normal control subjects.

(d) The fourth hypothesis implied, but did not predict, a main effect for shape. In addition, it was hoped that examination of the shape factor in conjunction with other factors (i.e., condition, group, and points) would enhance understanding of the processes that schizophrenics and others used when processing form. Thus, analyses of the simple, simple effects of the shape and points factors at the form task for schizophrenics were anticipated. These analyses were to be based on the $S \times P \times G \times C$ four-way interaction or on the $P \times G \times C$ three-way interaction findings.

(e) The fifth hypothesis used the $P \times G \times C$ 3-way interaction noted above in an analysis of the simple, simple effect of points at specific condition, at specific group. The simple, simple effect of points at number task for each of the subject groups was evaluated to determine which of the two theories were supported.

RESULTS

Condition Effect

This research reports the first attempt to test both numerosity and form perception with a single paradigm. The same stimuli and patterns were used in both conditions. Task instructions and practice trials prior to each experimental condition focussed subjects' attention to the salient attributes of the stimuli. Subjects were directed to attend either (a) to the number of points appearing briefly on the screen, without any mention or suggestion of an inherent shape; or, alternately, (b) to the permissible shapes, while disregarding the number of points configuring each shape. The first hypothesis, therefore, was intended to determine whether the two processes were differentially discriminated using this new paradigm.

The hypothesis was evaluated by the condition (C) main effect, by comparing the marginal mean for the number condition, with the marginal mean for the form condition. As predicted, the C main effect was highly significant ($F(2, 66) = 16.78$, $p < .0001$) indicating that the processing of number does differ from the processing of form. Examination of the univariate reaction time (RT) and accuracy results confirm that performance on the two tasks differs significantly on both of these dependent measures. The respective results for RT and accuracy follow: $F(1, 67) = 7.70$, $p = .0071$; and $F(1, 67) = 30.03$, $p < .0001$. RT is faster and accuracy is greater when judging number than when judging form. Mean RT and accuracy scores and the standard error of the mean (SEM) for the two conditions, are plotted in Figure 1. The accuracy differences, across

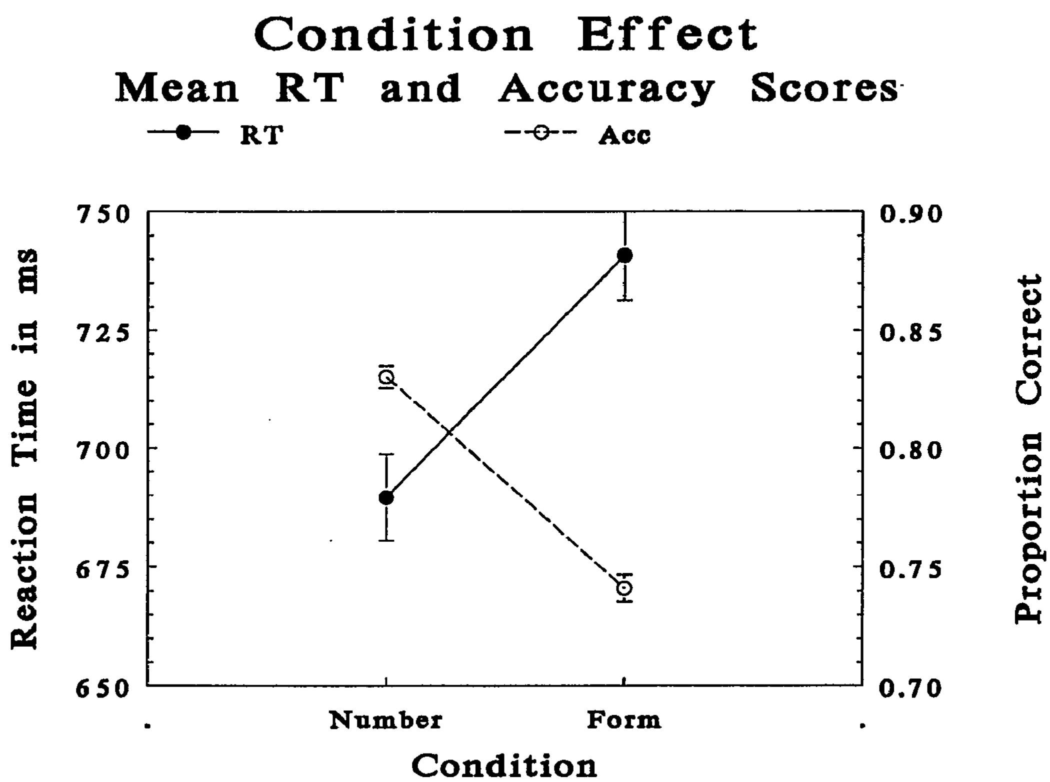

Figure 1. Reaction time and accuracy means and SEMs for the number and form conditions.

conditions, support the RT data; suggesting that greater speed of responding is not due to impulsivity or inattention, but indeed reflects quicker and better apprehension when counting points. These results provide evidence that our tasks tap different processing modes. Specifically, while number discrimination requires analytic processing, form discrimination requires holistic processing.

Condition × Group Interaction

Given confirmation for the first prediction, it became increasingly important to determine whether these two modes of processing were used equivalently by all groups. The hypothesis was that group differences would emerge with respect to the modes of processing required for the two tasks. This hypothesis implied a group by task (G × C) interaction which was further explored by examining the simple effects of tasks at each level of group.

We furthermore wished to test whether the expected differences were specific to schizophrenia, or to extreme psychopathology more generally. In addition, it was of interest whether the expected differences applied equivalently to subdivisions within schizophrenia or affective psychoses. The G × C interaction was, therefore, evaluated using several different group compositions. When four groups, comprised of all schizophrenics (group 1), bipolars only (group 2), C1s (group 3), and C2s (group 4) were used, the G × C effect was nearly significant ($p = .0505$). When all psychotics replaced "bipolars only," p rose to .0835. Expanding the G × C interaction to include all six groups, namely, acute and chronic schizophrenics (SA and SC), psychotic non-bipolars and bipolars (PN and PB), and both college and hospital adult controls (C1 and C2) resulted in non-significance ($p = .1399$). It should be pointed out that different partitioning of the groups results in different error terms for the relevant analyses. The

Table 2

Mean Accuracy Scores and Standard Errors for Each Group as a Function of Condition

	Schizophrenics		Psychotics		Controls	
	SA	SC	PN	PB	C1	C2
			Number Condition			
M	.8045	.8232	.8208	.8478	.8427	.8305
SEM	.0149	.0117	.0121	.0133	.0100	.0088
			Form Condition			
M	.7079	.7102	.7146	.6532	.7898	.7771
SEM	.0212	.0134	.0151	.0203	.0095	.0108

Note. The sample sizes for the groups are: SA acute schizophrenics = 8, SC chronic schizophrenics = 16, PN non-bipolar non-schizophrenic psychotics = 10, PB bipolar non-schizophrenic psychotics = 7, C1 BC controls = 22, C2 non-BC controls = 16.

failure to detect a significant interaction using the six-group comparison may be the result of the cells per group becoming too small and a lack of power to detect a difference. Table 2 lists the accuracy means and the standard error under each condition for each of the six groups. Inspection of Table 2 demonstrates differences in performance based on condition. All groups are equivalent in accuracy and perform in the 80-85% range on the number condition, simple G at number $p = .9995$. There is, however, considerable variability in performance for the form condition, simple G at form $p = .0393$. One might expect that this disparity between levels of condition would maximize the potential for a significant G × C interaction. As mentioned above, this interaction failed to reach significance ($p < .14$). Though disappointing, this result was not too troublesome, because our a priori predictions allowed for examining the simple effects of condition at each level of group, and for specific orthogonal contrasts.

Accuracy results of relevant a priori contrasts on the G × C interaction are presented in Table 3. Using the six groups defined above, several important comparisons emerge. Schizophrenics differ from controls at $p < .07$. Additional comparisons involving controls with either all other psychotics combined, bipolars only, or all patients combined, each differ significantly at $p < .01$. These comparisons might suggest that the four psychotic groups are undifferentiated from each other with respect to the two conditions. This is not entirely so. Bipolars differ from the other patient groups in their performance on these two tasks. The data in Table 2 are presented graphically in Figure 2. Inspection of this bar graph, and analysis of the simple effect of condition at each level of group yields the following important results. Each of the groups perform more poorly when required to make perceptual judgments about form rather than number. Each patient group found the form task significantly harder than number (SA $p = .0307$; SC $p = .0009$; PN $p = .0131$; PB $p = .0005$); while control group accuracy didn't differ significantly across tasks (C1 $p = .8045$; C2 $p = .1281$).

Table 3

Planned Comparisons from the Condition × Group Interaction on Accuracy Scores

Condition × Group-Comparisons	$F(1,67)$	p
C × SA+SC vs. C1+C2	3.54	.0642
C × PN+PB vs. C1+C2	7.09	.0097
C × PN+PB vs. SA+SC	0.90	.3462
C × PB vs. C1+C2	7.27	.0089
C × PN vs. C1+C2	2.09	.1532
C × patients vs. C1+C2	7.15	.0094

Note. SA = acute schizophrenics, SC = chronic schizophrenics, PN = non-bipolar non-schizophrenic psychotics, PB = bipolar non-schizophrenic psychotics, C1 = BC controls, C2 = non-BC controls.

Looking at the same data somewhat differently, one can calculate the percentage reduction in performance accuracy across tasks for each group. Form scores are about 5% lower than number scores for the controls. In comparison, acute and chronic schizophrenics, and non-bipolar psychotics are twice as impaired (10% loss). Bipolars are the most impaired, with a fourfold loss in performance (20% drop) relative to controls. Unlike the other psychotics, bipolars are both better and worse than all other groups. They are imperceptibly more accurate than controls on number processing, and

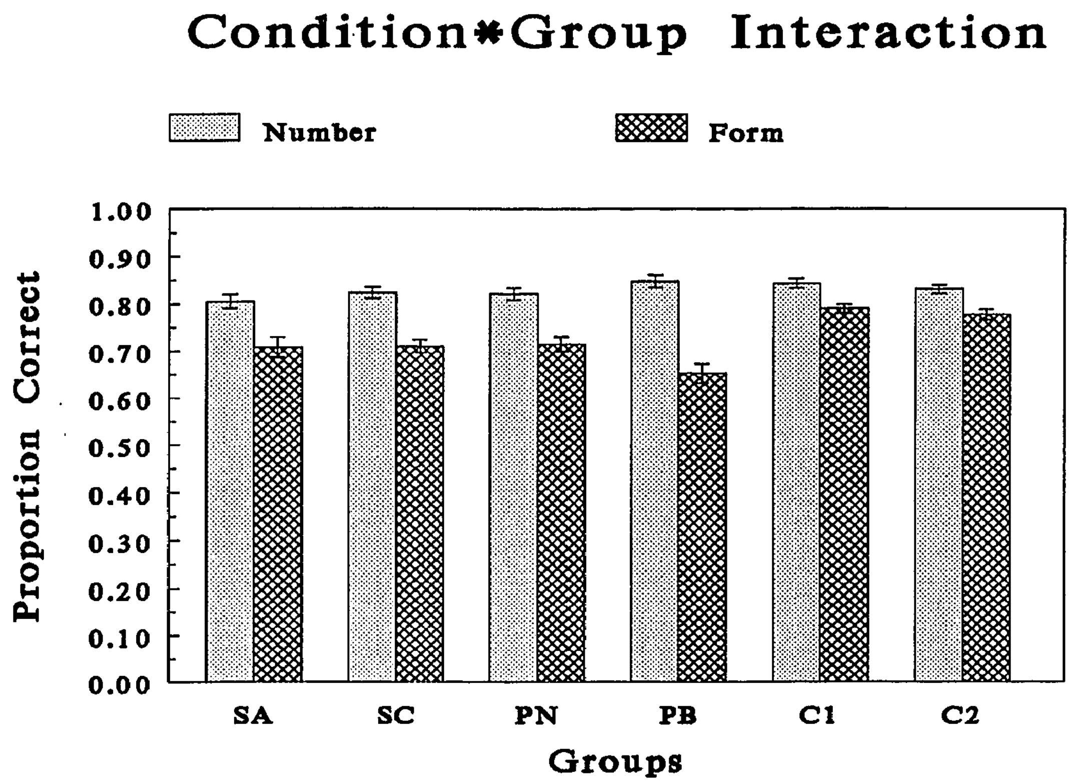

Figure 2. Accuracy means and SEMs for each of the subject groups as a function of condition.

considerably less accurate than all groups on form perception.

A priori contrasts on the simple G × C interaction effect are reported in Table 4. What becomes immediately apparent is that patient and control comparisons differ significantly on RT at the number condition, and on accuracy at the form condition. With

Table 4

Planned Comparisons for the Simple Effect of Group at Each Level of Condition

	Condition			
Group Comparisons	Number RT		Form Accuracy	
	$F(1,67)$	p	$F(1,67)$	p
SA+SC vs. PN+PB	3.51	.0653	.80	.3738
SA+SC vs. C1+C2	10.45	.0019	6.49	.0131
SA vs. C1+C2	4.09	.0470	3.62	.0616
SC vs. C1+C2	12.12	.0009	5.54	.0215
SA+SC vs. PN	3.24	.0764	1.83	.1803
SA vs. PN+PB	1.18	.2807	—	—
SC vs. PN+PB	4.82	.0316	—	—
C1+C2 vs. PN+PB	1.21	.2762	10.36	.0020
C1+C2 vs. PB	—	—	9.27	.0033
C1+C2 vs. PN	—	—	4.03	.0486
C1+C2 vs. Patients	6.12	.0159	11.45	.0012

Note. SA = acute schizophrenics, SC = chronic schizophrenics, PN = non-bipolar non-schizophrenic psychotics, PB = bipolar non-schizophrenic psychotics, C1 = BC controls, C2 = non-BC controls.

regard to number, controls are fastest, followed by bipolars, non-bipolars, and lastly by the schizophrenics. Chronic schizophrenics are significantly slower than non-schizophrenic psychotics ($p < .04$), but all schizophrenics differ marginally from other psychotics ($p < .07$), and are significantly slower than controls ($p < .01$). There are no significant differences in accuracy for the number condition.

Examining the contrasts on the simple G × C at form, reveals that controls are most accurate, followed by equivalent performance by the schizophrenics and non-bipolar groups, with the bipolars trailing. Unlike the comparison at number ($p > .28$), psychotic non-schizophrenics are significantly different than controls ($p < .01$). Schizophrenics alone, or in combination with the other psychotics differ from controls ($p < .01$). The form- and number-condition group means are presented in Table 2 and, graphically, in Figure 2.

The composite interpretation of these multiple analyses and planned comparisons, suggest (a) all groups are better at judging number than form, (b) there are no significant differences in accuracy amongst groups at number condition, and (c) analytic processing can be used advantageously by schizophrenic and other psychotic patients.

Delay Effect

The introduction of a cued delay in this paradigm was intended to yield two results. First, to shed light on the temporal processing features associated with each mode of processing; and subsumed to this, to determine if this time frame was equivalent for each of the groups. Secondly, to provide a mechanism, namely, more time for processing, to help each of the subject groups, but particularly the schizophrenics, to use gestalt processing. A small set of studies had shown that enhancing the salience of a stimulus (Cox & Leventhal, 1978; Knight, Elliott, & Hershenson, 1991a), or providing additional processing time (Kaswan, 1958), minimized the deficit of schizophrenics relative to controls on perceptual organization type tasks.

The hypothesis was that if a processing strategy is easily used and efficient, it is presumably more automatic (whether innately or learning derived). Alternatively, processing strategies that are less available, are clearly less automatic in one's repertoire. The prediction was not that schizophrenics were unable to use form processing at all, but that it was a less developed automatic strategy and that some additional help might mitigate the deficit or degree of deficit. The parameter time was intended to serve as that additional aid in the hopes of (a) tracking the optimal time course for each processing mode, and (b) tracking the time frame associated with the change, for each group, from automatic to less(er) automatic processing. It was predicted that these time frames would differ based on group membership and processing mode. Specifically, controls were predicted not to be affected by additional time when processing form, but to improve (shorter RTs or greater accuracy) for analytic processing. The reverse pattern was predicted for schizophrenics. Given schizophrenics' shorter attention spans, it was hypothesized that on a task which they did well, namely, number processing, too long delays might result in a decay in performance.

An examination of the effects of delay on the two task conditions, provides important clues for the types of processing and the associated time frames that are optimal for each group.

One of the most unambiguous results of this study is demonstrated in Figure 3. Delay has deleterious effects on accuracy for all groups at the form condition ($p < .0001$). Moreover, the pattern of decline is similar across all groups, with the greatest decline in performance occurring between 0 and 2 s; followed by a relatively steady state from 2 to 4 s. Though micro analyses (i.e., simple, simple delay at form condition at each level of group) show some variation among the groups, for example, acute and chronic schizophrenics, non-bipolar psychotics, and non-BC controls differ significantly ($p < .02$), BC controls are nearly significant ($p < .06$), and for the bipolars non-significance ($p > .09$); the overwhelming and correct interpretation of the accuracy data is a lack of a simple delay by group (D $\times$ G) interaction at the form condition ($p > .98$). It must be confessed, that this non-significant interaction, was initially worrisome. Specifically, the failure of controls to perform equivalently and optimally across all delay values, and, the lack of improvement with more time for processing by schizophrenics, when judging form, were counter to expectation. However, after puzzling about this result, the realization occurred that the predictions had been wrong and the findings were indeed reflective of the true nature of the underlying processes.

Briefly stated, it was recognized that the obtained results confirmed predictions from cognitive models of dual processing. These results demonstrate that holistic processing is most effective initially (at 0 delay) when apprehending a stimulus in a veridical,

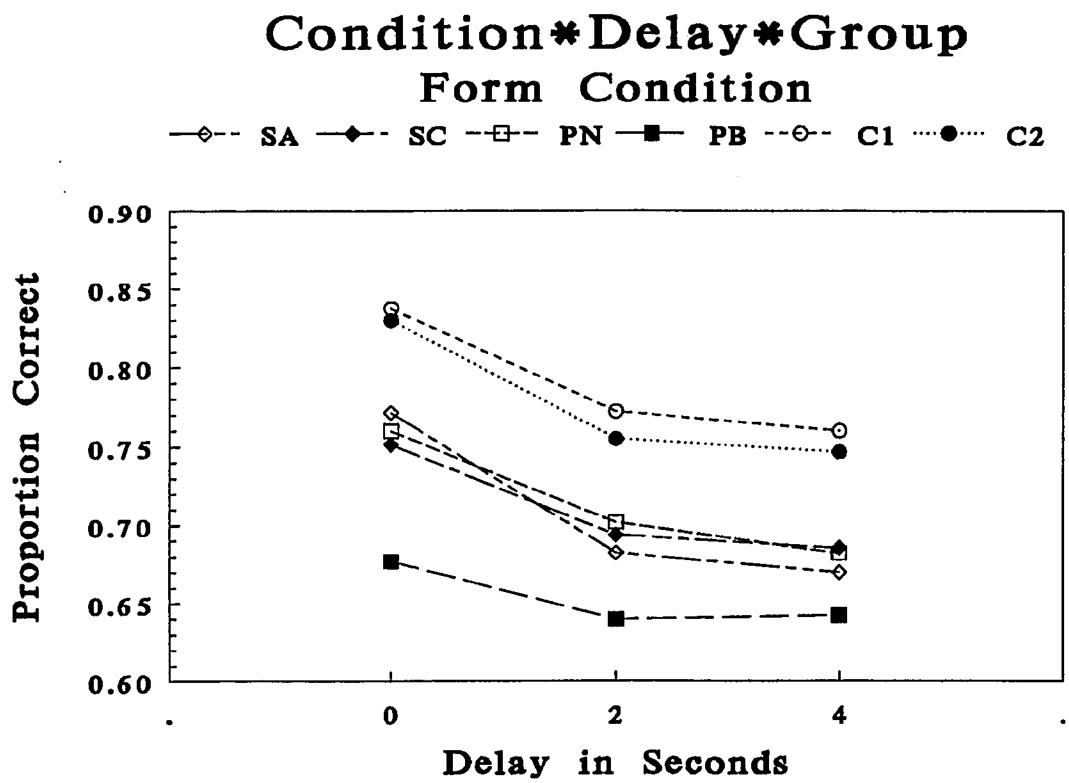

Figure 3. Mean accuracy scores for each of the groups as a function of the delay intervals at the form condition.

representative form, namely, in sensory or iconic memory. However, it is simply not a useful, effective process for the abstractive and encoding processes that occur post-stimulus offset in STVM or at longer delay intervals.

This interpretation is bolstered by a comparison of the effect of delay on number processing. Unlike the monotonic decline with greater elapsed time, seen for form processing, delay interacts with groups at the number condition, simple D × G at number, $p = .0502$. Figure 4 illustrates this. Consistent with the prediction, increased delay ameliorates control group performance, and diminishes accuracy for schizophrenics at the number condition (Delay × Group:schizophrenics vs. controls $p < .03$).

This significant three-way interaction is further disembedded into six graphs (Figure 5) for ease of comparison and communication. Generally speaking, the pattern of performance by the schizophrenic, psychotic, and control *subgroups* resemble one another, but they are dissimilar to the two other major categories of subjects. While the pattern of decline for all groups when processing form were similar, resulting in six almost parallel curves (Figure 3), performance on number processing results in curves that intersect and dip at differing values of delay depending on group membership (Figures 4 and 5). From 0 to 2 s, performance by schizophrenics remains relatively stable but psychotics improve, yet both groups decline from 2 to 4 s (Delay × Group:schizophrenics vs. psychotics $p < .05$). From 0 to 2 s psychotics appear to resemble controls. The latter continue to gain in accuracy with greater delay, but at the longest delay, psychotics resemble schizophrenics (Delay × Group:controls vs. psychotics $p < .07$).

For both conditions schizophrenics' best performance occurs immediately. While, delay does not affect number accuracy ($p > .12$), it does affect form accuracy ($p < .01$) for all schizophrenics. Psychotics, and the bipolar group in particular, are atypical. Their scores are most differentiated relative to the other groups with respect to the two

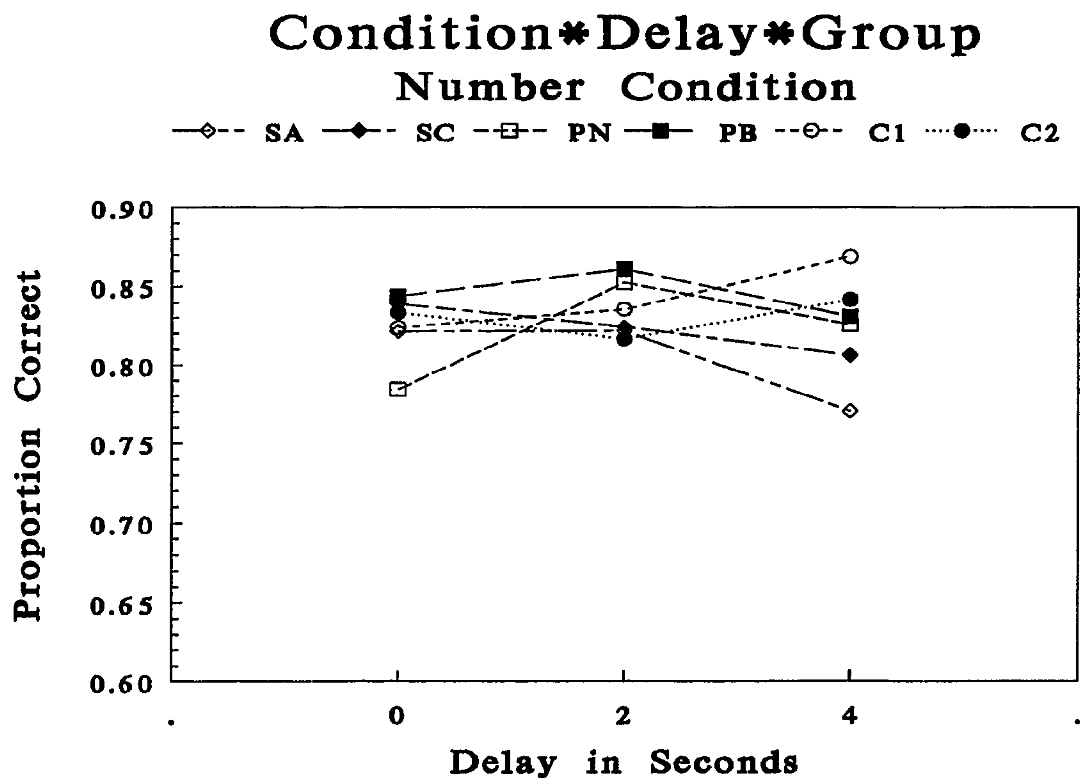

Figure 4. Mean accuracy scores for each of the groups as a function of the delay intervals at the number condition.

conditions. The non-bipolar psychotics are the only group to exhibit a significant delay effect at the number condition ($p < .03$); and the bipolars are the only group not to demonstrate a significant delay effect in either condition. Thus, for bipolars, processing for each condition remains relatively constant and unaffected by delay ($p > .09$).

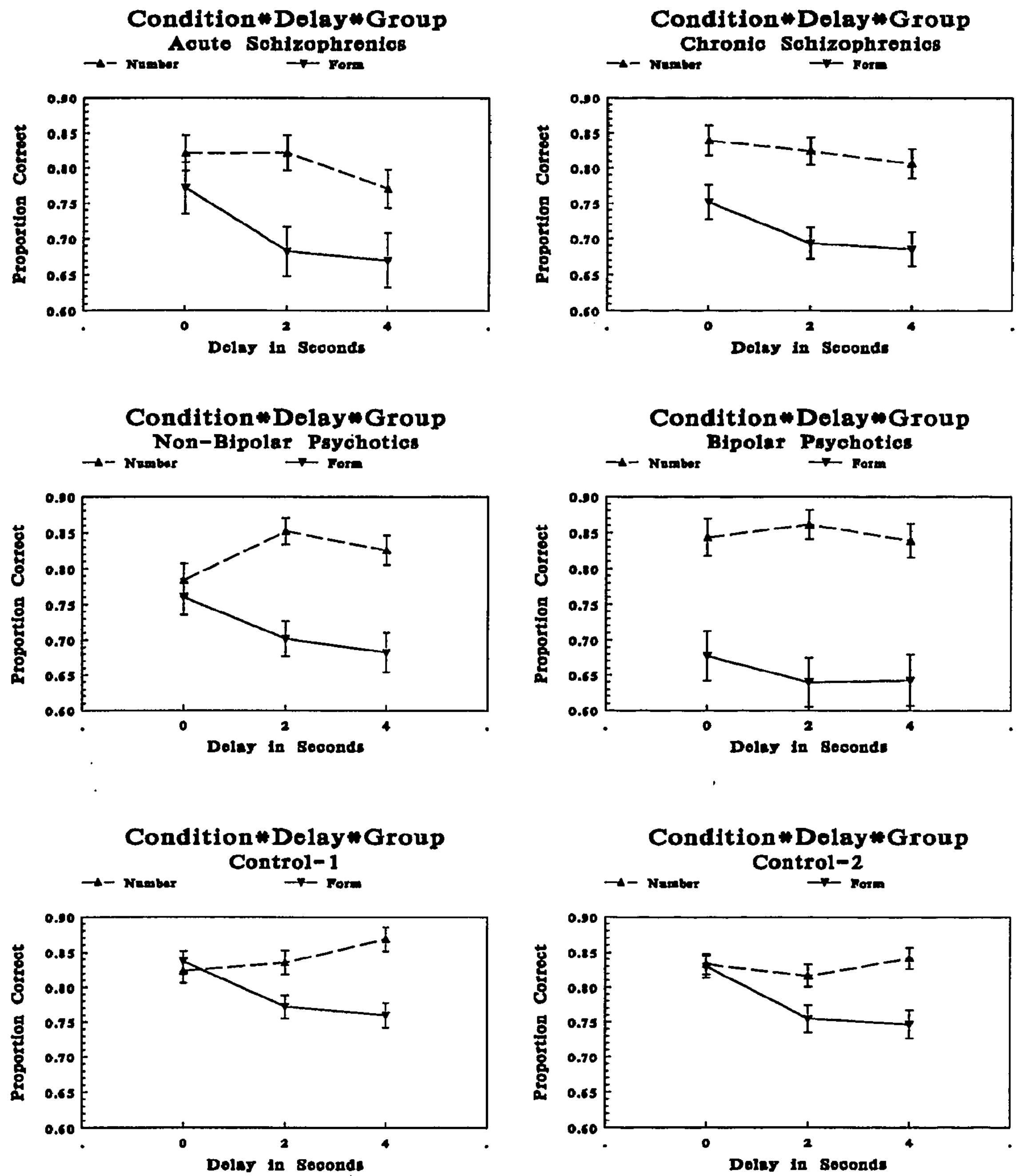

Figure 5. Mean accuracy scores for each of the groups as a function of the delay intervals at the number and form conditions.

RT means and SEM for all groups at both conditions are presented in Table 5. The effect of delay on RT for each group is highly significant, regardless of condition, ($p < .0001$). The most dramatic effect on RT occurs between 0 and 2 s. In general, response latency is approximately halved at the 2 s interval, with little or slight gain in speed thereafter. This suggests that the 0 to 2 s interval provides sufficient time for processing, and additional time is less helpful.

The simple D × G interaction is significant for the RT response variable at the number condition ($p = .02$), and different from the null hypothesis at the form condition ($p = .06$). None of the group contrasts are significant for the latter interaction at form, but patients vs. controls differ at ($p < .01$) for number RT. It is noteworthy that RT acts independently of accuracy. In other words, subjects' RT is considerably quicker at 2 s, regardless of whether delay improves or impairs response accuracy.

For the number condition, steady improvement in control group accuracy with increasing delay confirms that analytic processing normally occurs subsequent to global processing, and more time enhances analytic processing. There seems to be a trade-off such that as analytic processing becomes more effective, global processing is less operative. This is particularly true for normals, and for patients for the initial delay period. Patients may not continue to improve because their efficiency at analytic processing is somewhat impaired, and more time degrades their analytic (STVM) encoding.

These results confirm that holistic processing serves as an initial strategy, and additional time provides for analytic, abstractive, and encoding processes. This is especially true for normals. Schizophrenics and psychotics engage in the same two-step

Table 5

RT Scores and Standard Errors for the Simple Delay × Group at Condition Interaction

Group	Delay		
	0 s	2 s	4 s
		Number Condition	
SA	1344.0 ± 51.8	603.7 ± 39.5	546.0 ± 26.1
SC	1371.6 ± 29.5	644.4 ± 21.7	641.3 ± 22.9
PN	1287.4 ± 31.2	527.6 ± 29.9	492.3 ± 26.1
PB	1012.1 ± 35.9	479.2 ± 21.5	435.9 ± 17.1
C1	818.7 ± 25.2	390.2 ± 11.8	370.0 ± 10.7
C2	949.3 ± 26.0	452.8 ± 11.7	452.7 ± 17.3
		Form Condition	
SA	1246.8 ± 57.7	717.8 ± 42.9	635.7 ± 37.2
SC	1282.9 ± 33.3	729.6 ± 27.3	646.6 ± 23.7
PN	1341.9 ± 37.8	583.3 ± 33.9	523.5 ± 32.3
PB	1138.5 ± 48.8	626.8 ± 36.6	549.4 ± 33.6
C1	882.0 ± 20.0	431.7 ± 16.3	396.6 ± 13.7
C2	1113.1 ± 36.2	522.8 ± 21.9	484.7 ± 21.5

Note. SA = acute schizophrenics, SC = chronic schizophrenics, PN = non-bipolar non-schizophrenic psychotics, PB = bipolar non-schizophrenic psychotics, C1 = BC controls, C2 = non-BC controls.

process, but are much less efficient at holistic processing.

Points Effect

The results of the effect of increasing the number of the points distinguishes schizophrenics from controls. The manipulation of the points factor at the number condition was intended to determine whether this paradigm corroborated the superior numerosity findings of Place and Gilmore (1980) and the replications thereof (Wells & Leventhal, 1984; Orlowski, Kietzman & Dornbush, 1987), or the opposite findings, of decline with increased perceptual span, reported by Neale (1971), Asarnow and MacCrimmon (1978; 1981) and others.

Paradoxically, these data both support and rebut the Place and Gilmore (1980) findings. This disparity results from the differential effect of increasing points on the two task conditions. For the number condition, increasing the number of points does not affect schizophrenics' or psychotics' performance, but college controls' accuracy drops significantly ($p < .04$). These findings are in contrast to the perceptual span studies of Asarnow and MacCrimmon.

It is important to recall that the previous reports (Orlowski, Kietzman & Dornbush, 1987; Place & Gilmore, 1980; Wells & Leventhal, 1984) of superiority by schizophrenics resulted from their performance remaining *level*, when counting the increasing number of lines, while controls' performance *declined* under the same conditions. This is precisely the situation these data reflect. Like these investigators, we found that as the number of points increases, the controls' accuracy decreases. However, acute schizophrenics' accuracy remains relatively constant, and chronics improve slightly at the greatest number of points (Points × Group:schizophrenics vs. controls $p < .10$). This crossover pattern is evident in Figure 6, and in the individual graphs in Figure 7. The psychotics demonstrate

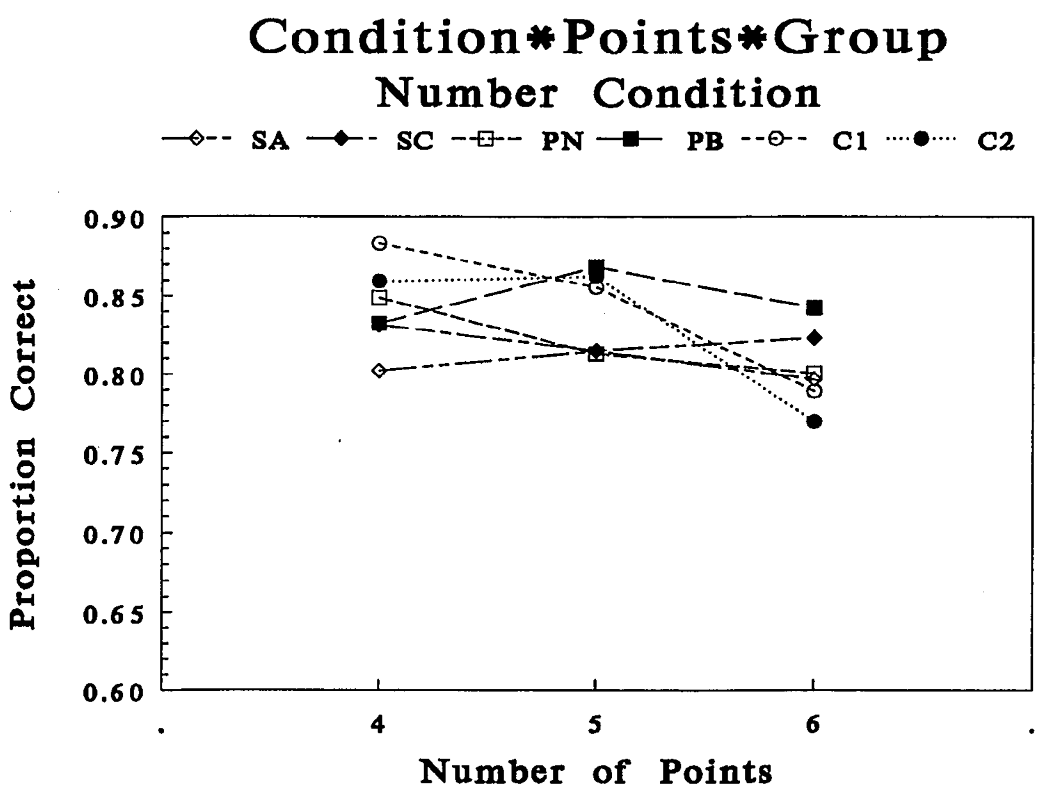

Figure 6. Mean accuracy scores for each of the groups as a function of the number of points at the number condition.

less uniformity than either of the other groups. Though the non-bipolars' gradual decline across increasing number of points, appears to resemble the controls' pattern, their decline

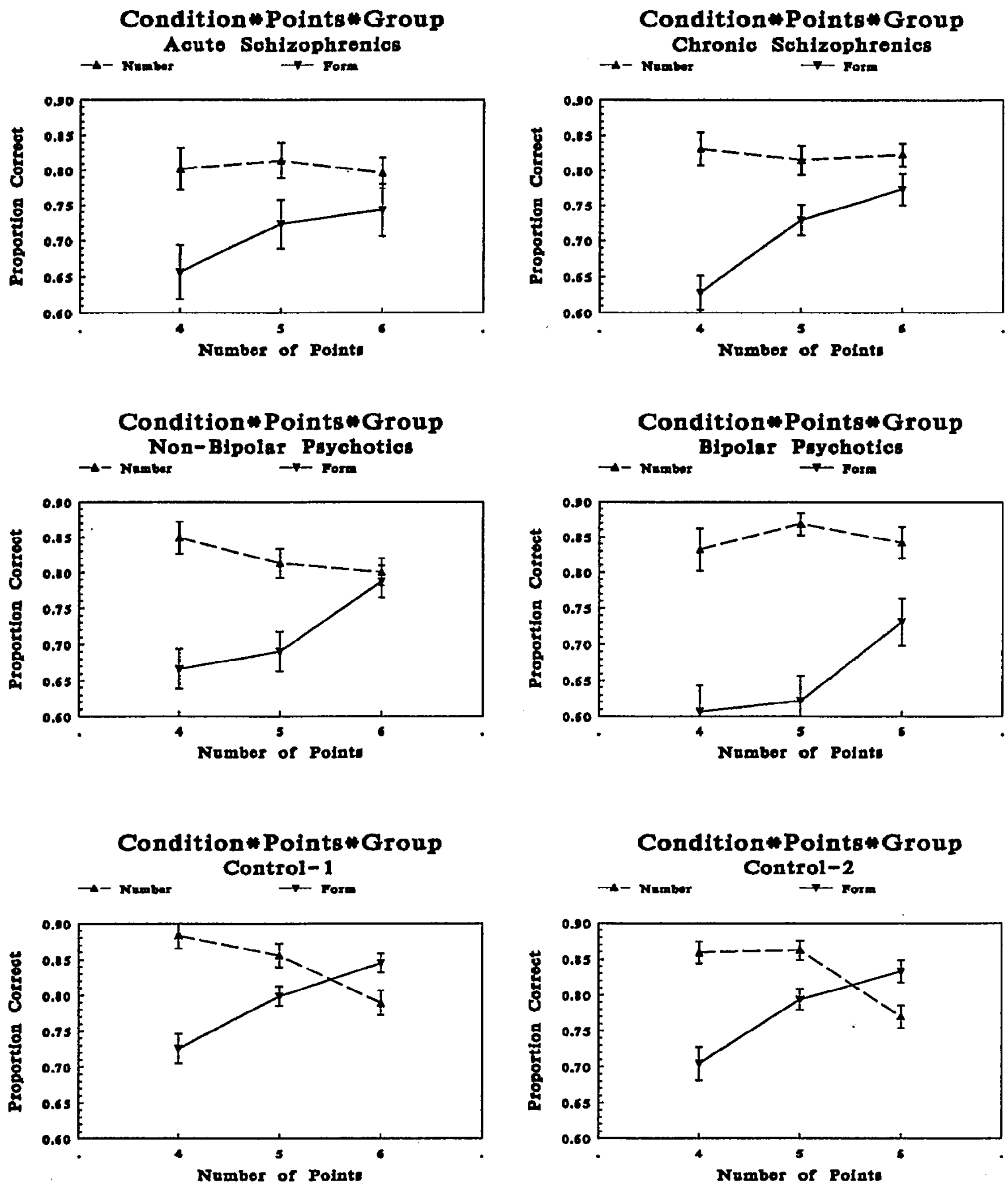

Figure 7. Mean accuracy scores for each of the groups as a function of the number of points at the number and form conditions.

is not significant ($p > .58$). The bipolars are atypical, and *improve* at 5 points, but then begin to level off. These changes in accuracy are likewise non-significant ($p > .78$). Only college controls' decline significantly in accuracy ($p < .04$), and there is a trend towards significance for the other control group ($p < .15$). The contrast between the control groups is non-significant ($p = .40$), suggesting that the control groups are in fact comparable and reliably different from the patient groups (Points × Group:patients vs. controls $p < .07$).

Form judgement accuracy improves significantly as the number of points increases ($p < .0001$). Though it was thought that all groups might profit from the presentation of additional points, this hypothesis was particularly intended to measure the effect for schizophrenics from 4 to 6 points. The results are compelling and are reflected in both improved accuracy and shorter RT scores. The simple, simple effect of points at form condition for each level of group is highly significant (save two exceptions) for both accuracy ($p < .02$) and RT ($p < .01$). These results are presented in Table 6. The exceptions are: (a) bipolar RT scores do not differ significantly, and (b) C1 controls' improvement in accuracy is likewise non-significant.

Inspection of Figure 8 reveals that when processing form, the pattern of improvement differs between groups (Points × Group:psychotics vs. controls $p < .07$; Points × Group:psychotics vs. schizophrenics $p < .04$). Psychotics differ most dramatically from both schizophrenics and controls. Controls improve linearly from 4 to 6 points; while schizophrenics improve most from 4 to 5, and then gain more slowly from 5 to 6 points. Psychotics show little change from 4 to 5, but catch up at 6 points.

Table 6

RT and Accuracy Results for the Simple, Simple Points Effect at the Form Condition for Each Group

Group	RT		Accuracy	
	F^a	p	F^b	p
SA	6.77	.0021	4.26	.0161
SC	9.56	.0002	18.99	.0000
PN	5.48	.0064	9.14	.0002
PB	1.76	.1787	6.56	.0019
C1	5.21	.0080	2.02	.1361
C2	8.09	.0007	15.63	.0000

Note. SA = acute schizophrenics, SC = chronic schizophrenics, PN = non-bipolar non-schizophrenic psychotics, PB = bipolar non-schizophrenic psychotics, C1 = BC controls, C2 = non-BC controls.

[a]The Huynh-Feldt corrected *df* for these analyses are 1.86, 124.46. [b]The *df* associated with these analyses are 2, 134.

Collapsing across all levels of the points factor, schizophrenics do not differ significantly from controls. Although the absolute accuracy scores of the schizophrenics are lower than those attained by the controls, the pattern of improvement as a function of increasing

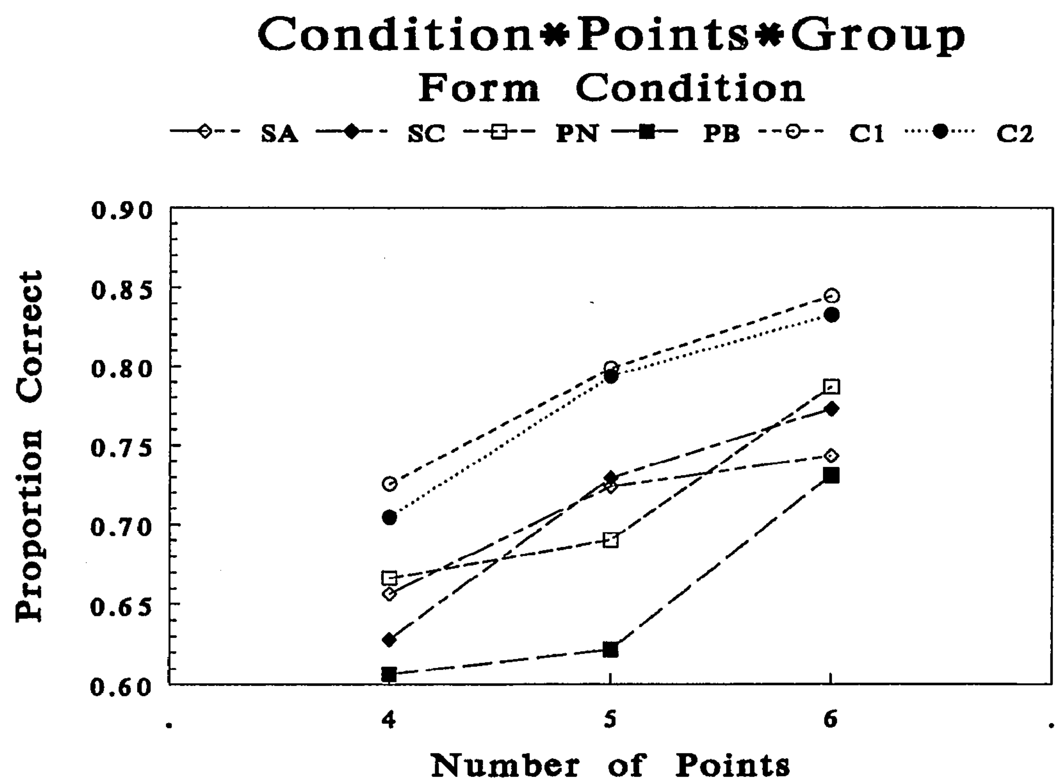

Figure 8. Mean accuracy scores for each of the groups as a function of the number of points at the form condition.

points is similar. However, consider these two caveats. Comparisons between schizophrenics and all controls might fail to differ significantly because the two control groups differ with respect to the effect of increasing points on form perception. College controls' accuracy is not significantly affected by increasing points ($p > .13$), but the other control group's accuracy is affected ($p < .0001$). Yet, interestingly, the specific group contrast, C1 vs. C2 for the simple P × C interaction at form is non-significant, $p > .24$. This result and the almost identical curves in Figure 8, argue that the control groups do not differ from each other. Additionally, the schizophrenic vs. control contrast at 4, 5, and 6 points are each significant ($p < .04$). These and other significant contrasts for simple points at form are reported in Table 7.

The mean RT scores for each level of the three-way points by condition by group (P × C × G), are plotted in Figures 9 and 10 respectively. What becomes immediately apparent is that for the number condition, RT scores lengthen for all groups with increasing number of points; and the reverse holds true for the form condition. Accuracy and RT are inversely related for both conditions. The difference in the directionality between RT and accuracy for each of the conditions, underscores that our tasks have been successful at distinguishing analytic and holistic processing. When counting is the task, additional points take more time; but when it's the form that has to be perceived, the gestalt is processed holistically rather than point by point. This improves both accuracy and speed of responding.

While the effect of points at number are consonant with the Place and Gilmore (1980) and subsequent literature, the enhanced performance by schizophrenics on the form task are contrary to their implications. Patient groups can use additional cues to their advantage when organizing a percept. Corroborating Cox and Leventhal (1978), these findings demonstrate that when the salience of a form is enhanced, the perceptual-organization deficit of schizophrenics is diminished.

Table 7

Group Contrasts at the Form Condition for Each Level of Points

Group Comparisons	Number of Points					
	4		5		6	
	F^a	p	F^a	p	F^a	p
SA+SC vs PN+PB	0.04	.84	4.21	.05	0.05	.83
SA+SC vs C1+C2	6.23	.02	4.83	.04	4.61	.04
PN+PB vs C1+C2	6.20	.02	16.36	.01	4.78	.04
PN vs C1+C2	2.50	.12	6.68	.02	1.63	.21
PB vs C1+C2	5.44	.03	14.26	.01	4.59	.04
Ptns[b] vs C1+C2	8.48	.01	13.63	.01	6.41	.02

Note. SA = acute schizophrenics, SC = chronic schizophrenics, PN = non-bipolar non-schizophrenic psychotics, PB = bipolar non-schizophrenic psychotics, C1 = BC controls, C2 = non-BC controls.

[a]The *df* associated with these individual group comparisons are 1, 67.

Shape Effect

What is the effect of the shape (S) factor? Do these differences depend on condition or not? Does number of points have an effect on shape? A specific shape?

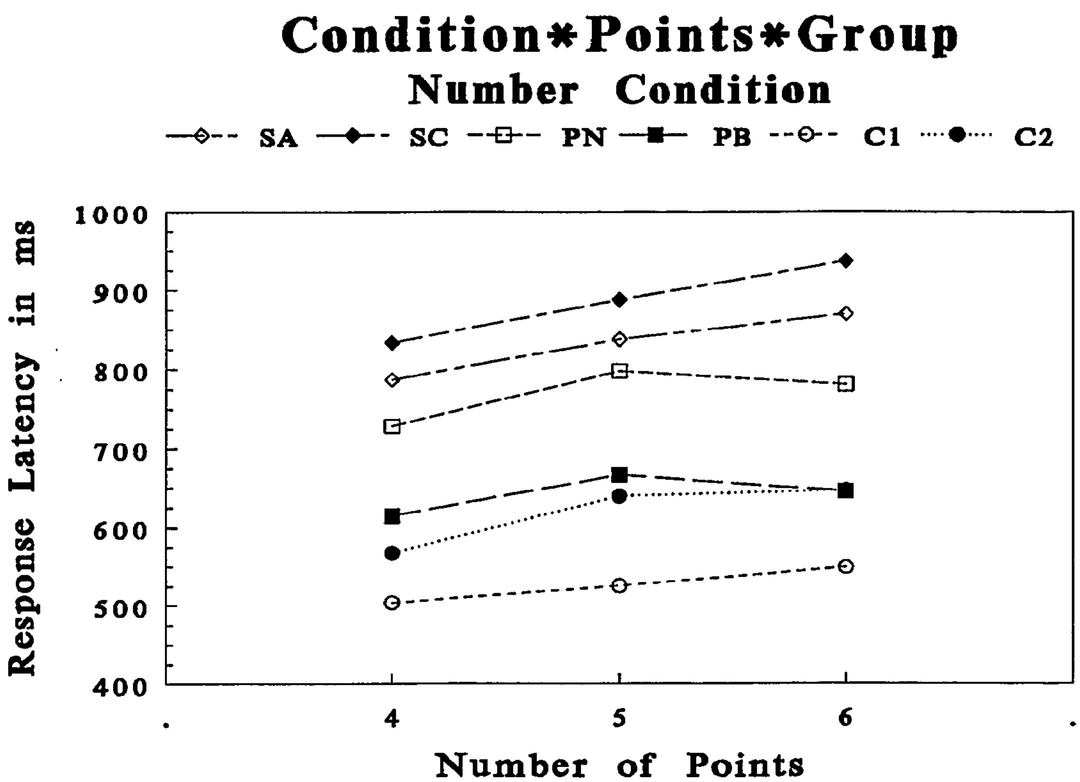

Figure 9. Reaction time means and SEMs for each of the groups as a function of the number of points at the number condition.

Do groups differ in which shape is easiest or hardest, or with respect to these other factors? The predictions related to these questions were uncertain. This research involved a new paradigm, and it was not known what the shape manipulation would yield. Prior research (Mikitish, 1985) had demonstrated that controls were better at processing

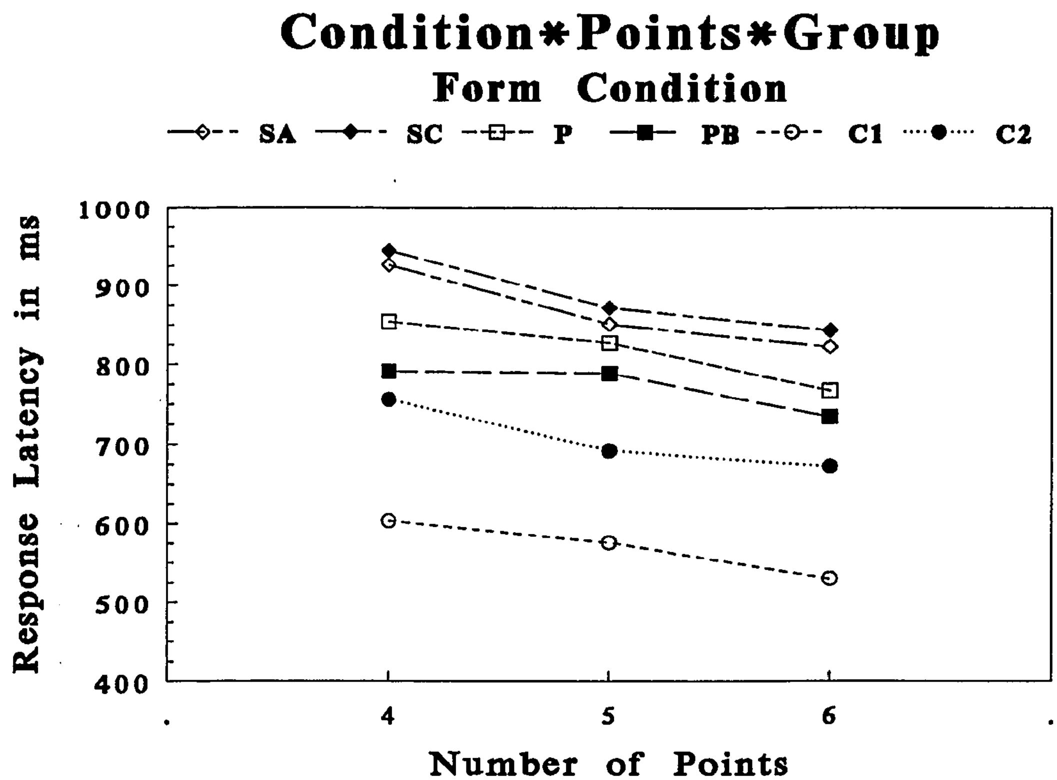

Figure 10. Reaction time means and SEMs for each of the groups as a function of the number of points at the form condition.

geometric shapes than numbers, but had not indicated a superiority for a specific shape, nor were comparisons made with any psychotic groups.

Moreover, it was of theoretical interest to ascertain what attribute would enhance discriminability among the shapes. It was reasoned that: (a) if *familiarity* facilitates accuracy, then *square* would be best, because patients were most able to describe or recognize the criteria for squares, with little or no prompting, or with minimal instruction; (b) if *more information* helps most, then *rectangles* would be most discriminable, because the rectangle is the only one of the three shapes to provide an additional dimension, namely, length or width ; and, lastly, (c) if *most novel* provided the greatest salience, *rhombuses* would be easiest, both because schizophrenics tend to be attracted to and to attend better to novel stimuli, and the "parallelogram" aspect of the rhombus was less known to them.

To assess these effects, we examined the data from the main effects (i.e., S) through the various interactions (i.e., S × C, S × P, S × G, S × C × P) of the larger four-way (i.e., S × C × G × P), always with an emphasis on the *group* effect either via a priori contrasts, or via analyses of simple effects on the groups.

The accuracy results for the S main effect were highly significant: $F(2, 134) = 25.61$, $p = .0001$. Mean accuracy scores for the square, rectangle and rhombus shapes are, respectively, 75%, 84%, and 76% correct. The S × G interaction was not significant, but specific group contrasts (i.e., sub hypotheses) from this interaction do demonstrate differences between all patients and controls ($p = .0528$), and particularly between schizophrenics and controls ($p < .02$). In addition, by examining the simple effect of shape at each level of group it can be determined that the effect of the different shapes is highly significant for each of the four psychotic groups ($p < .01$), and for the adult hospital controls ($p < .04$), but not for the college controls ($p > .23$). This latter finding is unusual, especially since a comparison of the two control groups on this factor is non-significant.

The shape by condition (S × C) interaction was similarly investigated to ascertain whether the discriminability of the three shapes was affected by the task manipulation. Mean accuracy scores for each of the shapes are approximately 83% at the number condition, when shape is a latent cue. The accuracy means for the square, rectangle and rhombus shapes at the form condition, are 68%, 85%, and 69% respectively. The supremacy of the rectangle shape is also reflected in the mean RT scores. In ms, the respective RT scores per shape at the form condition are: 747.40, 727.00, 748.30. Thus, the S × C interaction was highly significant for accuracy: $F(1.98, 132.69) = 27.76$, $p = .0001$, and for RT: $F(2, 134) = 4.91$, $p = .0088$. Examining the simple S effect at each level of condition, yielded significant difference at both conditions for accuracy (S at number, $p < .05$, and S at form, $p < .0001$), and for RT only at the number condition ($p < .001$).

We further examined the three-way S × C × G in two ways. Group contrasts on the S × C interaction involving schizophrenic vs. controls, and schizophrenic vs. other psychotics, were each significant at the same level ($p < .04$). However all patients vs. controls did not differ significantly ($p > .13$).

Results from the simple, simple effect of S at (each level of) C, for (each level of) G, make it abundantly clear that shape had no effect on performance for any of the groups at the number condition, but had significant effects on each of the psychotic groups at the form condition. Stated differently, performance for the three shapes did not differentiate the groups when processing number, though the non-bipolars showed a marginal trend toward greater improvement on rhombuses.

Significant differences, depending on the particular shape, were noted amongst the groups when processing form. This latter statement applies predominantly to the patient groups. Although controls also differed in accuracy depending on which shape was presented, there is the somewhat anomalous finding that the effect for college controls is non-significant ($p > .14$), but is significant for the hospital adult controls ($p < .01$). What is curious is that their range of decline from highest to lowest accuracy for the shape factor is identical to the college controls', and the C1 vs. C2 group contrast from the S × C × G is totally non-significant ($p > .98$) indicating that the groups don't really differ. Two factors probably contributed to the apparent disparity. The degree of loss from one shape to another is not identical (even though the total decrease in accuracy is), and the groups' difference in size. The results from the three-way interaction corroborate the above S findings.

Mean accuracy scores and SEM for the S × C × G interaction are reported in Table 8. Inspection of this table 8 yields several interesting findings. The most compelling result is that when processing form, the rectangle is clearly the most discernable shape. Ancillary to this, is the observation that the rectangle does not impact on performance for the number condition, despite its clear salience when processing form. The second result to notice is that the pattern of best to worst shape discrimination depends on group membership. Thus schizophrenics find rectangle easiest, followed by rhombus, and last by square. For them, despite their greater familiarity with squares, it is least

Table 8

Accuracy Scores and Standard Errors for the Simple Shape × Group at Condition Interaction

Group	Shape		
	Square	Rectangle	Rhombus
		Number Condition	
SA	.8098 ± .0260	.8038 ± .0255	.8006 ± .0262
SC	.8106 ± .0220	.8208 ± .0203	.8382 ± .0185
PN	.8056 ± .0243	.8043 ± .0208	.8525 ± .0168
PB	.8377 ± .0256	.8446 ± .0252	.8610 ± .0180
C1	.8373 ± .0187	.8439 ± .0165	.8471 ± .0166
C2	.8314 ± .0157	.8195 ± .0149	.8406 ± .0150
		Form Condition	
SA	.5348 ± .0433	.8284 ± .0300	.7605 ± .0249
SC	.6265 ± .0278	.8157 ± .0165	.6884 ± .0214
PN	.6469 ± .0278	.8678 ± .0175	.6291 ± .0243
PB	.5737 ± .0381	.8223 ± .0231	.5635 ± .0329
C1	.7832 ± .0177	.8746 ± .0124	.7115 ± .0166
C2	.7479 ± .0195	.8700 ± .0143	.7135 ± .0195

Note. SA = acute schizophrenics, SC = chronic schizophrenics, PN = non-bipolar non-schizophrenic psychotics, PB = bipolar non-schizophrenic psychotics, C1 = BC controls, C2 = non-BC controls.

accurately perceived. The psychotics' pattern is rectangle first, with no clear preference between square and rhombus. The controls do best on rectangle, followed by square, and least well on rhombus. Within these groups, the two schizophrenic sub-groups differ most from each other. Surprisingly, the acute schizophrenics perform both best and worst with respect to two of the shapes. They are most impaired on squares, but better on rhombus than all other subjects. Their chronic counterparts display a narrower range of scores (≈20% as compared to almost 30% for the acutes), and they are comparable with controls: simple Shape × Group:chronic schizophrenics vs. controls at Form, $p > .35$, acute schizophrenics vs. controls, $p < .01$, and all schizophrenics combined vs. controls, $p < .02$.

The two non-schizophrenic psychotic subgroups resemble each other in pattern, but not in degree, on this effect. Similarly to other effects discussed above, bipolars' performance both surpasses and underperforms non-bipolars at number and form processing respectively. Both groups are best at distinguishing rhombuses for the number condition, with this approaching significance for the non-bipolar group ($p < .07$). It is interesting that when psychotic non-schizophrenics are required to actively process shapes, they recognize squares and rhombuses *equivalently*.

The issue of whether shapes are affected by the (number of) points (S × P) was likewise addressed. Above, the report is of the beneficial effect of increasing the number of points for form discrimination. Herein, we examine whether this effect is uniform for the different shapes, and how this interacts with any of the groups. The focus is on S ×

P at the *form* condition, because this interaction was not significant at the number condition for any of the groups.

Both RT and accuracy means for the four-way S × P × C × G are displayed in Table 9. Examination of this detailed table suggests several interesting results. As a general rule, regardless of particular shape or group membership, more points results in improved form discrimination accuracy and quicker responses. (The square shape, however, shows a "V" pattern from four to six points, primarily for accuracy).

This is especially true for the rhombus shape, with average (across groups) improvements of 30% correct detections for six-point rhombuses as opposed to four-point rhombuses. Steady improvement for the rectangle shape is similarly found, but the rate of change is less dramatic. On average, more points result in an 11% gain, yet the rectangle remains the most accurately perceived shape.

Discrepancies to this general pattern are equally important. Of note, acute schizophrenics look different than all other groups. Two potent indicators demonstrate that they do not respond in a comparable manner to increases in the number of points configuring a shape; and that they differ from the chronic schizophrenics as well. The range of improvement within a given shape is smaller for the acute schizophrenics than for the other groups. For example, for the rhombus shape it is about half (16%) the typical gain, yet they surpass (slightly) even the controls at six points. This group is the only one *not* to decline in response to the five-point square presentation, and the only group to excel (relatively speaking) at the four-point rhombus stimuli. Indeed, controls do considerably worse than acute schizophrenics on these stimuli, but comparably to

Table 9

RT and Accuracy Means at the Form Condition for Shape × Points × Group Cells

Points	Variate	Shape		
		Square	Rectangle	Rhombus
		SA Acute Schizophrenics		
4	RT	977.7±115.7	908.8±101.7	892.6±100.8
	Acc	.5368±.0783	.7493±.0622	.6833±.0463
5	RT	872.7± 94.6	858.7± 89.9	822.3± 92.3
	Acc	.5439±.0725	.8720±.0449	.7557±.0358
6	RT	891.4±101.3	817.4± 98.2	759.1± 92.7
	Acc	.5236±.0774	.8640±.0454	.8425±.0420
		SC Chronic Schizophrenics		
4	RT	967.8± 85.5	923.6± 71.1	942.1± 60.6
	Acc	.6663±.0468	.7117±.0313	.5059±.0381
5	RT	910.8± 61.0	822.9± 60.6	881.0± 58.3
	Acc	.5956±.0461	.8515±.0268	.7412±.0273
6	RT	856.0± 56.3	861.4± 59.1	811.8± 58.1
	Acc	.6177±.0518	.8839±.0208	.8181±.0294

(table continues)

Table 9 (continued)

Points	Variate	Shape		
		Square	Rectangle	Rhombus
		PN Non-bipolar Non-Schizophrenic Psychotics		
4	RT	815.9± 86.0	827.1±100.3	920.5± 93.2
	Acc	.7106±.0449	.8127±.0362	.4761±.0395
5	RT	841.3± 86.6	826.4± 97.6	814.8± 94.1
	Acc	.5263±.0491	.8897±.0363	.6546±.0331
6	RT	786.6± 88.7	766.4± 87.9	747.2± 90.0
	Acc	.7038±.0440	.9009±.0209	.7565±.0372
		PB Bipolar Non-Schizophrenic Psychotics		
4	RT	756.7± 89.6	785.7± 94.3	832.2± 94.2
	Acc	.6270±.0665	.8036±.0419	.3889±.0465
5	RT	856.7± 85.8	733.5± 88.4	776.8± 99.9
	Acc	.4806±.0580	.8155±.0462	.5696±.0491
6	RT	727.7± 78.7	764.2± 97.6	710.4± 91.3
	Acc	.6135±.0710	.8479±.0318	.7321±.0507

(table continues)

Table 9 (continued)

Points	Variate	Shape		
		Square	Rectangle	Rhombus
		C1 BC Controls		
4	RT	528.0± 39.3	648.9± 46.1	634.6± 43.0
	Acc	.8207±.0362	.8299±.0237	.5267±.0323
5	RT	594.1± 41.4	557.4± 41.1	577.2± 39.4
	Acc	.7452±.0275	.8812±.0208	.7703±.0173
6	RT	545.7± 34.7	497.4± 32.0	547.7± 39.3
	Acc	.7838±.0268	.9128±.0184	.8376±.0183
		C2 Non-BC Controls		
4	RT	715.8± 68.4	746.8± 68.6	805.2± 67.5
	Acc	.7837±.0383	.7943±.0308	.5354±.0401
5	RT	712.8± 62.4	658.9± 59.1	704.7± 62.6
	Acc	.7253±.0292	.8786±.0223	.7780±.0197
6	RT	691.9± 59.6	608.9± 46.7	716.5± 70.3
	Acc	.7347±.0334	.9372±.0142	.8270±.0213

chronic schizophrenics in accuracy. Group contrasts on the simple S × P interaction effect at the form condition demonstrate this result. Thus, for this interaction, acute schizophrenics differ significantly from controls ($p < .04$), but chronic schizophrenics don't ($p < .85$), and a similar discrepancy is noted in comparisons with the other two psychotic groups: acute schizophrenics vs. psychotic non-schizophrenics differ significantly ($p < .03$), but chronic schizophrenics do not ($p < .32$).

The other particularly anomalous group are the bipolars. They have the most depressed scores on the four-point rhombus, but can avail themselves of more points and make steady, dramatic (44%) improvements from four to six points. Bipolars also show the smallest net gain when processing rectangles configured of more points. Similarly to the other groups, save the acute schizophrenics, they also decline at the five-point square. Furthermore, specific stimuli (e.g., 5 point-square and 4 point-rhombus) have proven difficult. Perhaps, though it is not apparent why, these particular stimuli combinations do not serve as good gestalts. Examples of experimental stimuli appear in Appendix B.

When examining the simple, simple S × P interaction effect at the form condition at each level of group (i.e., a piece of the four-way S × P × C × G), it is evident that increasing the number of points has a highly significant effect on accuracy for the psychotic non-schizophrenic and control groups ($p < .0001$). This is however not true for *either* schizophrenic subgroup: acute schizophrenic, $p > .27$; chronic schizophrenic, $p > .84$. Looking at the data (Table 9) it is hard to understand these non-significant findings, particularly for the chronic schizophrenics. They, more than the acutes, resemble the other groups. In addition, a higher-ordered effect, namely the simple S × P interaction effect at each level of group is likewise highly significant ($p < .005$) for all groups, *except* the acute schizophrenics ($p > .78$). Despite these latter findings, the means reported in Table 9, support the premise that a shape is more quickly and more accurately apprehended when more data (in the form of more points along the perimeter of the shape) are available. The prediction that the perception of a(ny) shape would be facilitated by increasing the number of points used to configure a shape, was thus confirmed.

DISCUSSION

This research concerned the evidence for a perceptual organization deficit in schizophrenia. Methodologically, this research evaluated the processes subjects were required to engage in to count points or to perceive form successfully; ascertained the temporal referents for the mechanisms employed; and determined if reliable group differences existed with respect to the modes of processing. The discussion is structured to demonstrate that the obtained results are consistent with the literature on dual-processing models in normal populations. Subsequently, the data computed on the schizophrenic and other psychotic groups is assessed to illustrate both the corroboration with and departure from the earlier perceptual organization body of research derived on schizophrenic patients. Neurophysiological data that have relevance to this research will also be described.

A fundamental result of this study is the confirmation that visual apprehension of external stimuli occurs in a two-step process. This study does more, however, than confirm prior models of cognitive information processing. It provides evidence that two-step, sequential, time-linked processes hold true not only for normal control subjects, but they have applicability for understanding processing by psychiatric patients as well. Numerous investigators (Coltheart, 1980; Knight, 1985, 1991; Kroll & Hershenson, 1980; Loftus & Ginn, 1984; Loftus, Hanna & Lester, 1988; Navon, 1974; Phillips, 1974; Potter, 1976; Rosen & Hershenson, 1983), though differing in the precise articulation of these processes have nonetheless expressed convergence on the content, nature, duration, limits and sequencing associated with these two early information processing domains.

A distillation of these authors' formulations follows. Neisser (1967) labelled the earliest-occurring visual information processing store "iconic memory," and based on the work of Sperling (1960) he conceived it as a veridical, large capacity sensory store. Subsequent research by the investigators cited above led to a reformulation of the Neisserian iconic store as encompassing two distinct and separable stages. The first stage, named the sensory store by Phillips (1974), was defined as a, relatively unlimited, high capacity store that decayed rapidly, presumably within 100 ms or so. This duration is not finite for all stimuli or circumstances, but it is dependent on additional factors such as attributes of the stimuli or task, and the degree of familiarity/automaticity of the viewer with these stimuli. The important point about this sensory store is that it is a short-lived stage which allows for a perceptual representation of the incoming stimulus, which is processed in parallel and to a sufficient degree to allow for the immediate identification of the gist of the input (Loftus et al., 1988; Phillips, 1974; Potter, 1976). That this first stage, first approximation at cognitive processing, occurs in a global and parallel fashion was confirmed in the same-difference matching paradigms of Kroll and Hershenson (1980) and Rosen and Hershenson (1983).

Phillips defined the latter stage, which he named short-term visual memory (STVM), as a limited capacity store that decays more slowly, typically lasting up to 600-1000 ms. Like the first stage, this duration may be extended to even several *seconds* depending on the complexity of the task and the amount of attentional effort allocated to it. Again, it is important to understand what the nature/work of STVM is. The STVM stage takes the perceptual representation generated in stage one and turns it into a conceptual representation via the allocation of processing capacity and resources. The critical factor herein is in the decision to allocate further attentional processing to the stage one output to the degree or depth of processing (Craik & Lockhart, 1972) required. Stimuli in this store are processed serially, by focussing attention on the individual elements (Loftus et al., 1988; Kroll & Hershenson, 1980; Rosen & Hershenson, 1983). Within STVM, allocation of resources can be directed to the *type* of process requiring attention. Though designed typically to process analytically, the unit of measure might be more than each individual item, depending in part on the perceptual organization and chunking that took place within the stage one perceptual representation store (R. A. Knight, personal communication, August 1991).

STVM provides a brief temporal window that allows for an abstracted, encoded visual memory rather than a perceptually representative memory. This results in the consolidation of the visual input for subsequent recognition (Potter, 1976; Potter & Levy, 1969), for utilization in working memory (Baddeley, 1986; formerly called STM), or for more permanent memory storage (LTM), providing a basis for future comparisons.

It should be noted that, with the exception of Knight, these formulations of early information processing were derived in research on normal populations. These investigators provide irrefutable evidence that these two processes work in tandem, suggesting that normals process visual inputs in a global manner followed by an analytic mode.

Knight either alone (1984, 1987, 1989) or in collaboration (Knight & Elliott, 1991; Knight, Elliott, & Hershenson, 1991a, 1991b) extended this line of research, arguing that precisely by retaining models generated to explain normal cognition, and testing them on psychiatric populations, can one (a) generate testable theories and (b) acquire information regarding disordered thinking and perceiving in schizophrenic and other psychiatric populations.

In agreement with Knight's premise, this study draws on the cognitive theories derived from normal populations, as well as from the perceptual organization literature developed from the testing of schizophrenic patients. To this end, this research manipulated several factors (including delay, point, and condition variables) to learn about the types of processes schizophrenics and other psychotics engaged in, and, more specifically, to determine the time frames associated with the putative types of processes used. In addition, this study set out to ascertain if the sequence of processing modes differed between patients and controls.

Perceptual organization research can be segregated into two groups. Studies that have demonstrated "superiority" by schizophrenics have used counting tasks; they have bolstered the impression that schizophrenics use analytic type processing advantageously, perhaps to the exclusion of holistic processing (Orlowski, Kietzman, Dornbush & Winnick, 1985; Place & Gilmore, 1980; Silverstein, Raulin, Pomerantz & Patrey, 1988; Wells & Leventhal, 1984). Investigations that have concerned themselves with the deficit in applying gestalt processes (Cox & Leventhal, 1978; Frith et al., 1983; Kaswan, 1958; Knight, Elliott, & Hershenson, 1991a, 1991b; Snyder, 1960; Snyder, Rosenthal, & Taylor,

1961) have highlighted deficiencies in invoking and applying grouping principles, without attending too much to the latter analytic stage of processing. Together, these sets of studies suggested greater reliance and better performance on analytically oriented tasks and the reverse finding on perceptual grouping tasks. A major inference from the extant literature was that schizophrenics *either* bypassed or used inefficiently global structuring and perceptual organization. However, the conclusions of the cited studies left ambiguous which model (i.e., bypass the first global stage, or deficiencies in its use) best described both the mode(s) of processing employed, and the sequencing and time frame associated with the mode(s) used.

These studies are two sides of the same coin, yet their implications are different. If the correct interpretation of these studies is that schizophrenics bypass a first stage of processing, namely, the gestalt, holistic stage, this would indicate an exclusive reliance on the latter stage of analytic processing. Moreover, such a model would suggest that schizophrenics processed information in quite a different way from normals, perhaps using only one process. If, on the other hand, the deficit is due to an inefficient application of the global process, it would indicate that schizophrenics use both processes, but that there is a deficit in the initial global store which could be manifested either in the stage one sensory store, or in STVM. Deficits in either the sensory/perceptual memory or in the encoding and conceptual representation would be correlates of such a model.

Studies by Eriksen and Collins (1967), Spaulding et al. (1980), and Knight, Sherer, Putchat, and Carter (1978) using successive-forms dot- and picture-integration tasks have already provided definitive evidence that the earliest-occurring store is intact in schizophrenic patients. Magaro and coworkers (Magaro & Chamrad, 1983; Magaro, Johnson, & Boring, 1986; Magaro & Page, 1982), Braff and Saccuzzo (1981, 1985), and Saccuzzo and Braff (1981), drawing on their extensive backward masking investigations, have likewise confirmed that the original iconic store functions adequately in schizophrenia. These researchers have located the deficit in either the encoding (Magaro, Johnson, & Boring, 1986; Magaro & Page, 1982), or in the transfer processes (Braff & Saccuzzo, 1981, 1985) which temporally coincides with the latter stage, namely, STVM, of the dual-process model.

Support for the applicability of this model to the deficiencies and capabilities of schizophrenics arise from the recent studies of Goldman-Rakic (1987, 1991, in press) and Park (1991) and Park and Holzman (1991). The paradigm in these studies allowed for the separation of these two memorial stores by either keeping the target on throughout the testing session (i.e., tapping sensory guided memory), or turning it off for either 5 or 30 s delay periods (i.e., tapping spatially guided *representational* memory). The target was a lighted disk on an oval dial with eight possible positions. Subjects were either non-human primates, with or without lesions in the prefrontal cortex (Goldman-Rakic), or schizophrenics and controls (Park, Park & Holzman). Subjects were prevented from rehearsing by the introduction of either a fixation dot or an irrelevant task during the delay intervals. After the elapsed time, subjects were required to indicate the target by turning their eyes (their heads were fixed in a head-rest) toward the correct position. All subjects performed well on the sensory-guided tasks, but the lesioned animals and schizophrenics were disadvantaged on the representationally-guided memories. One must bear in mind that these investigators use the term *representational* memory analogously to the above described conceptual and working memory representations, rather than to the earlier occurring perceptual representations. They refer to these memories as "out of view" but "in mind" (Goldman-Rakic, 1987, 1991).

These worthwhile and fascinating studies shed light not only on the cognitive modes of processing which are impaired, but they also provide compelling evidence for the neurophysiological and neuroanatomical substrate underlying these deficits. A pivotal contribution of these studies is the brain mapping of the structure and function of these cognitive processes. By various sophisticated neuroanatomical techniques, including PET scans, radioactively-labelled dopamine tracers, measurements of neuronal density, and, very importantly, recordings from specific neurons (while the target was *on* or *off*), these researchers have localized the deficit. These investigations prove unequivocally that an intact prefrontal cortex is necessary for the regulation of behavior by "the temporary holding of *representations* of stimuli in (working) memory" (Goldman-Rakic, 1991, in press). Neurons in the prefrontal cortex access the relevant representations and hold them "on line" for up to several seconds to guide a response. Neurons are organized in a topological map in Area 46 and along the principal sulcus; they continue firing for several seconds after a stimulus is out of sight to retain it in mind. These areas receive projections from and innervate complex and sometimes distal systems—that is, thalamic, limbic, hippocampal and nigrostriatal pathways. This area is not localized for retaining sensory memory, thus providing an unambiguous technique to segregate the two memorial stores on the basis of structure and function.

The present study did not investigate the presence of the early occurring memory stores via neurophysiological or neuroanatomical mechanisms. However, the specific tasks used in this experiment, and in particular the delay and point manipulations, were intended to tease apart purely sensory (iconic) memory from higher-ordered representational, abstractive memory, via the processes subsumed therein. Earlier studies had confirmed that the structural aspects of sensory memory were intact in control and schizophrenic subjects (Braff & Saccuzzo, 1981, 1985; Eriksen & Collins, 1967; Knight et al., 1978; Magaro, Johnson, & Boring, 1986; Magaro & Page, 1982; Saccuzzo & Braff, 1981; Spaulding et al., 1980). Therefore it remained for this study to investigate the processes, or functions, of this and the subsequent memory store, to unravel what contributes to the attentional, perceptual deficits of schizophrenics.

A priori, and swayed by the evidence of superior performance by schizophrenics on the numerosity tasks in other studies, the prediction was that schizophrenics would excel at the number task in this study. More importantly, additional time, as exemplified by longer delays, was expected to preferentially aid schizophrenics, particularly, on the task that was believed to result in compromised performance. The logic was as follows. It had been proven that schizophrenics could do an analytic type task. Therefore, more time wasn't required or going to be very helpful for such tasks. Perhaps too much time would even be detrimental.

It also seemed, based on the evidence, that analytic processing was their primary mode of processing. With respect to holistic processing, schizophrenics performed poorly. Two possibilities emerged. Either they needed additional time to process globally, because this was more difficult for them; or the normal sequence of processing, namely, global followed by analytic was reversed in these patients. Either possibility suggested that additional processing time, in the form of longer delays, would facilitate or improve performance. Three delay values were selected: 0 (no) delay, 2 s and 4 s. If schizophrenics simply needed more time to process globally, because their encoding processes are deficient (Long, 1980; Magaro & Page, 1982; Magaro et al., 1986), or slower (Braff & Saccuzzo, 1981, 1985; Saccuzzo & Braff, 1981) one would expect improvement on the form task from the 0 to 2 s interval. If schizophrenics had a different crossover pattern than normals, such that analytic processing preceded global processing, then greatest improvement in form processing would be expected to occur between the 2 to 4 s interval. Either result would have been informative, but our results contradicted both of these predictions. Initially disappointing and puzzling, the disconfirmation has actually been a boon. The obtained results in fact lead to a more parsimonious and elegant explanation and correspond well with the alternative hypothesis of deficiencies in the dual-process model detailed above.

One of the least ambiguous findings of this research lies in the effect of delay on the two separate conditions and in particular on the form condition. Control groups are clearly best at global processing both initially and at subsequent delays, but schizophrenics also demonstrate global processing ability at zero delay. Delay has deleterious effects on performance for all groups, with the most rapid decline between 0 and 2 s. Evidence for the effective *duration* of global processing is bolstered by a comparison of the delay effect on number processing. Consistent with our a priori prediction, delay enhances control group performance, but schizophrenics' accuracy declines at the maximal delay. Essentially these results confirm that holistic processing is most effective initially (at 0 delay) when a stimulus is in a veridical, representative form in sensory memory. However it is less useful for the abstractive and encoding process that occur post-stimulus offset in STVM or beyond.

Akin to the delay findings, the interaction of the points factor with the task conditions highlights the relevance of the dual process model. Control and schizophrenic competencies and deficiencies fit the prediction of this model. Consistencies with respect to form processing, and divergencies with regard to number, are the crucial data to unravel the processes used by the respective groups.

Increasing the number of points potently affects form perception. All groups improve in accuracy and in (shorter) RT scores, contradicting the Place and Gilmore (1980) findings. The significant improvement by schizophrenics confirms that they can use a global process when given additional information or cues. Proof? There are several lines of evidence. Firstly, their pattern of improved global performance shares similarities to that of the normals, though the achieved performance level is lower. Secondly, the RT data is informative vis-a-vis the two conditions. RT scores lengthen with increasing number of points for the number condition, but the reverse holds true for additional points at form. Accuracy and RT are inversely related for both conditions, establishing that the point manipulation was successful at discriminating analytic from holistic processing. When counting is the task, additional points take more time. However, when the form has to be perceived, the gestalt is processed holistically rather than point by point, expediting response time while improving accuracy.

Performance on the shape variable provides further corroboration that certain factors can minimize schizophrenics' perceptual organization deficit. The overwhelming impression is that the rectangle shape is clearly the most discernible. Despite idiosyncratic differences between acute and chronic schizophrenics, and between these subgroups and the other groups on other aspects of the S × C × G × P, schizophrenics are best at rectangles as well. Though they evince greater verbal familiarity with the square, the strength of the rectangle shape presumably derives from the additional cues (i.e., the dimension of length or width) intrinsic to this shape. These findings validate and extend those of Kaswan (1958) and Cox and Leventhal (1978). These investigators had mitigated performance differences between schizophrenics and controls, on their tasks, by increasing the salience of the perceptual groupings. Furthermore, the data indicate that the perceptual organization deficit is not due to a lack, or absence, of global processing, but rather to a deficient global process that requires enhancements to induce this type of process.

This refutation of the Place and Gilmore (1980) and subsequent perceptual organization studies emanate from the form perception findings. By contrast, the obtained results with respect to number are consistent with that literature for number processing. The effect of the points factor at the number condition discriminates schizophrenics from controls. The finding that control subjects decay with increasing number of points, while schizophrenics' performance remains relatively constant when processing number, supports the theory that gestalt and perceptual structuring exert greater pull on controls than schizophrenics. Controls are very accurate at detecting four points, but their performance declines slightly at five points and precipitously at six. This pattern demonstrates that the controls are responsive to the latent, inherent structure of the stimuli which is enhanced by additional points. Clearly, more points improve form and detract from the element by element counting process. This is consonant with the Place and Gilmore (1980), Wells and Leventhal (1984), and Orlowski, Kietzman, Dornbush, and Winnick (1986) findings that controls are affected by the gestalt properties of a stimulus. However, the pull of the global aspects intrinsic to the stimuli can be counteracted when controls are given more time to process, as demonstrated in controls' improved number perception accuracy as a function of delay.

Again, in agreement with Place and Gilmore (1980) and the replications thereof, the schizophrenics see less inherent structure, and they are able to proceed with the number task unimpeded. The evidence for this derives from their pattern of responding. Schizophrenics' performance doesn't vary as a function of increasing the number of points, and they outperform controls at the maximal number of points to be counted. Their "superiority" on counting more elements derives from the comparison with the controls, who *decline* in performance.

Within the context of the prior perceptual organization literature, these new data suggest an interpretation different from the one previously attributed to the schizophrenics. Schizophrenics are not, a priori, analytic processors while controls are global processors. Schizophrenics' superiority lies in their ability to hold more elements (in mind) as discrete and separable, in circumstances which are disadvantageous to controls. This does support a lesser reliance on global processing and perceptual organization for schizophrenics, but it doesn't ipso facto suggest greater proficiency at analytic processing. Controls attend to the demand characteristics imposed by the differing levels of the delay and point variables when processing number. The finding for schizophrenics of a consistent, relatively invariant, pattern to the analytic task of differentiating number, is in contrast to the controls' attentional pattern. This suggests that schizophrenics do not allocate additional attentional resources for further depth of processing. This is the task of the STVM, and their performance is consistent with a deficit at this stage. This deficit is contingent on their weaker gestalt processing, and it will become more evident when gestalt processing is clearly a prerequisite.

Given the tandem nature of the global/analytic dual process model, deficits in global processing would invariably compromise performance in the subsequent/consequent STVM process. If the function of the global process is to derive a representation of the gist of the stimulus to permit encoding and abstracting of information for meaning, memory, and behavior in STVM and beyond, then diffuse, less automatic or inefficient gestalt mechanisms will result in poorer consolidation in STVM. But if less rigorous global processing is sufficient, or involves easily encodable material, namely, a number, then schizophrenics and other psychotics can perform comparably with controls. One might even argue, that when one takes into account the nature of their illness and the attendant symptomatology, comparable performance under these circumstances, clearly translates into competence by schizophrenics for this process.

Confirmation for the validity of this revised interpretation of the nature and extent of the perceptual organization deficit derives, ironically enough, from an examination and comparison of the two studies that Place and Gilmore (1980) conducted. In both experiments, the requirement was to count the number of lines presented. The experiments differed in that in experiment one stimuli were presented along with noise elements (i.e., circles) which were not to be counted, and in experiment two no circles were presented. Schizophrenics' performance declined in experiment one even in those situations where no noise circles occurred; but in the latter experiment, schizophrenics' performance exceeded controls when counting five or six lines which were perceptually grouped in two or three clusters.

A general conclusion can be culled from these and related studies, such as the span of apprehension (SOA) (Asarnow & MacCrimmon, 1978, 1981; Neale, 1971; Strauss, Bohannon, Stephens, & Pauker, 1984), and backward masking (Braff & Saccuzzo, 1981; Miller, Saccuzzo, & Braff, 1979; Saccuzzo & Braff, 1981) paradigms. Schizophrenics will be impeded on *analytic* processing when the task first entails a holistic process (i.e., segregating or seeing the natural clusters) operating on the stimuli before moving into the analytic mode. When, inherent or imposed, gestalt or configural aspects can be safely disregarded, schizophrenics can (apparently) blithely and successfully process analytically. Normals, who appear either hard-wired or developmentally conditioned to notice and automatize global characteristics first (Schneider & Shiffrin, 1977; Shiffrin & Schneider, 1977, 1984), will take longer and do less well when required to attend *solely* to the analytic aspects in the early stages of processing of stimuli. For controls, analytic processing clearly gains in usefulness within a few seconds of the arrival of the input.

A question that arises is: "Where do the non-schizophrenic psychotics, and the bipolars in particular, fit vis-a-vis the dual process models?" Are they more similar to the normals, or do they resemble the schizophrenic psychotics? Speaking generally, the data indicate that perceptual organization deficits are not restricted to schizophrenia; but the affective psychotics are not carbon copies of the schizophrenics either. Some of the most interesting, if surprising, findings in this study are derived on the bipolars. Bipolars typically displayed the most extreme scores. Bipolars differed from the other patient groups in their performance on the two tasks. They were better than the non-bipolar and schizophrenic psychotics on number processing, closely approximating the normals; and they were twice as impaired as these patients, relative to controls, on form perception.

Dual process models have provided the theoretical tools with which to examine and cut the proverbial Gordian knot of attentional processing in schizophrenia. Similarly, examining the performance of the non-schizophrenic psychotics may bear on whether schizophrenia and affective disorders are on a continuum, or may even overlap in certain cognitive processes (Harrow, Grossman, Silverstein, & Meltzer, 1982), or are rather clearly separable diagnostic entities (Spitzer, Williams, Gibbons, & First, 1988). As reported earlier, delay impairs form processing for all groups, and it improves number processing for controls. The non-bipolar affectives are the only psychotic group to exhibit a significant effect of delay at number; and the bipolars are the only psychotic group not to display a significant effect of delay at form. All groups process form better with additional points. Schizophrenics perform more poorly than controls, but their pattern of responding is roughly parallel. Psychotics differ most dramatically in terms of their pattern of improvement, and bipolars differ in degree as well, from the other groups. For the points effect at number, the affective psychotics demonstrate less uniformity than either the schizophrenics, who remain level, or the controls, who decline. With respect to the shape factor, psychotics resemble the other groups in preferring rectangles, but, unlike the others, they process squares and rhombuses equivalently. Additional points affect shape perception for psychotics and controls, but not for schizophrenics.

These data indicate that distinctions among psychotic patients have merit. On some results, psychotics are intermediate between schizophrenics and controls. Better performance by manics and bipolars has also been reported in the SOA literature by Asarnow and MacCrimmon (1981) and in the spatial delayed memory tasks of Park and Holzman (1991). In general, non-bipolar psychotics are more similar to schizophrenics than bipolars are. Bipolars, for their part, either surpass all patients, closely resembling the controls, or are significantly more impaired than all others. The latter pattern is true for number and form processing respectively. A composite interpretation of these data yields the surprising finding that bipolars are even poorer global processors than schizophrenics, and they are better at analytic processing than other psychotics. Could it be that bipolars are the purer perceptually "disorganized" (Orlowski, Kietzman, Dornbush & Winnick, 1985) group?

Inclusion of the two non-schizophrenic psychotic groups has enriched the data set on perceptual organization and provided a valuable mechanism for clarifying similarities and differences among diagnostic groups. One interpretation of the difference between the schizophrenics' and bipolars' performance may reside in the state-trait split. Comparisons between the psychotic groups suggest that the state-trait dimension has more validity for the affectively disordered groups than for the schizophrenics. The number of bipolar subjects was small, but, on the positive side, this group was a homogeneous one, with six of the seven having the illness for (much) less than two years, and all suffering a current episode. The non-bipolar affectives had much longer prior psychiatric histories, more frequent hospitalizations, and, generally, numerous episodes. This 2:1 chronic:acute split is mirrored in the schizophrenics. But, while few differences have emerged on these tasks within the latter group, there is greater performance variability with the affective psychotics.

The state-trait dichotomy is consistent with reports on the utility of SOA as a vulnerability marker. In those studies, Asarnow and MacCrimmon (1981) found greater impairment in the schizophrenic than in the manic-depressive group, who were intermediate between the schizophrenics and controls. Strauss, Bohannon, Stevens, and Pauker (1984) failed to replicate, finding no significant differences between their schizophrenic and bipolar-manic or bipolar-depressed groups. One source of difference between the studies is that Asarnow and MacCrimmon (1981) used remitted outpatients while Strauss et al. (1984) studied inpatients. Strauss and coworkers attempt to reconcile the disparity by suggesting that reduced SOA performance may be a marker of manics only during episodes of the disorder, but it may be present both during and between episodes in schizophrenics, reflecting a more persistent vulnerability in schizophrenia.

This would coincide with the perspective of Asarnow and colleagues (1981) that SOA is a trait vulnerability marker that is "likely indexing a schizophrenic diathesis rather than current (clinical) state" (Asarnow & MacCrimmon, 1981, p. 1010). One might add that for the manics it would act as an episode, rather than trait, marker. This explanation is applicable to the observed pattern of results obtained in this study as well. One might speculate that the state-trait dimension modulates the perceptual organization deficit. A deficit in global processing may be an indicator of psychosis which gets exacerbated during episodes of the illness.

There is one final item that bears addressing. This study is important in regard to the attentional information processing literature in schizophrenia and psychosis. Comparisons of schizophrenics and controls in varied attentional paradigms have continuously reported performance decrements by schizophrenics. This has led Chapman and Chapman (1973) to view most attentional research as flawed, by virtue of the competing hypothesis of generalized deficit. This alternative interpretation suggests that schizophrenics will always be found to perform more poorly, not because of real differences attributable to task performance, but due to characteristics indigenous to schizophrenia. Given the nature of motivational and attentional impairments in schizophrenia, the Chapmans (1973) reject the findings of specific deficits on the grounds that these reflect psychometric artifacts.

Recently, some investigators have challenged the Chapmans argument. Counter strategies have included: (a) testing *two* control groups, for example, elderly and young samples (Orlowski, 1986; Saccuzzo & Braff, 1981) in comparisons with schizophrenics;

(b) deriving theoretical models to develop tasks and specify a priori patterns of performance (Knight, 1984, 1987); and (c) finding tasks that result in superior performance by schizophrenics. The research reported on herein successfully rebuts the generalized deficit hypothesis by incorporating all of these measures. The sensitivity of the patients to the experimental manipulations of this paradigm provide clear and compelling evidence that schizophrenics evince specific processing deficits. Moreover these deficits can be mitigated under controlled conditions.

In conclusion, this research extends the extant perceptual organization literature in several important ways. Besides corroborating the finding of a perceptual organization deficit in schizophrenia, (Orlowski, 1986; Place and Gilmore, 1980; Wells & Leventhal, 1984), this study describes the conditions and factors that amplify or mitigate the deficit. This study examines the processes that underlie these deficits, and determines that they are neither "all or none" nor irreversible. Additional psychotic, but non-schizophrenic, groups were examined to determine the specificity of the deficit to schizophrenia or to psychoses more generally. Finally, similarities between this study and those investigating prefrontal cortical dysfunctions in schizophrenia (Goldman-Rakic, 1987, 1991, in press; Park, 1991; Park & Holzman, 1991), propose a neuroanatomical locus for the STVM deficits reported herein.

APPENDIX A

Informed Consent Forms for Patients and Controls

New York State Psychiatric Institute-Columbia University Department of Psychiatry P. 1 of 6

INFORMED CONSENT FORM FOR PATIENTS

Perceptual Organization in Schizophrenia (PIRB Protocol #1784)

Principal Investigator:Dr. Lewis A. Opler (212) 305-4575/
Dr. J. Gibbon (212)960-2472(3)

Co-Investigator: Esther Rabinowicz Telephone No: (212) 960-2200 Ext. 676

Name of Participant:________________________________

Purpose of Study: The purpose of this study is to understand more about the relationship between mental processes and psychiatric symptoms. Specifically, I have been asked to participate in this research to study how patients like myself and other individuals respond to visual stimuli.

Description of Study Procedures: If I choose to participate, I will be seated in front of a computer (video) screen, on which dots will be briefly flashed. I will be asked to remember and report certain information about the visual display, such as the number of dots I saw flashing.

If my doctor feels it is alright for me, I will leave the ward on an accompanied pass to Psychiatric Institute (a walk of about 5 minutes), to the unit where testing will take place. For patients who cannot be escorted off the unit, testing may take place on Neuro-12.

The total time of the study, including practice and testing, will take between 1 and 2 hours. I will be given several short breaks (2 minutes each), and one longer break (10 minutes) during the test session. If I feel tired, upset, or don't wish to continue, I may withdraw from the testing at any time. If I am unable to complete the testing in one session, and if I wish, I may complete it in two sessions.

Expected Risks and Benefits: There are no known risks involved in this study. None of the procedures are hazardous or invasive. There are no foreseeable medical or psychological risks. If, however, I feel fatigued, uncomfortable, or in any way upset during any part of the study; I may ask for a rest break or to discontinue the study.

I know that these studies are being done for research purposes and that I probably will not benefit directly. However, the knowledge gained through my participation may provide future benefits for individuals with mental health problem in terms of improved understanding, diagnosis and treatment.

I will be compensated for my participation in this study, and at completion of the testing session I will be paid $10.00. In addition, because this study involves a video screen, it may provide some fun and a change in the routine of the ward.

Perceptual Organization in Schizophrenia (PIRB Protocol #1784)

Informed Consent Form For Patients

Principal Investigator: Dr. Lewis A. Opler-Tele. No:(212) 305-4575

Research Standards and Rights of Participants: The nature of this study has been clearly explained to me both in writing and verbally. I understand that my participation in this study is strictly voluntary. I have the right to refuse to participate in, or to withdraw from this study at any time should I choose to participate; without my treatment being withheld or changed in any way. I have the right to withdraw from this experiment at any time, if I do choose to participate. I understand that whether I participate or not in this research, will not affect my regular clinical care, or any future clinical care, at either Presbyterian Hospital or at New York State Psychiatric Institute.

I understand that my right to privacy and confidentiality of my participation in this project, should I choose to participate, will be safeguarded. All information obtained in this study will be kept in a locked office and will only be available to the responsible researchers. When the research findings are published or presented, no individual identifying information will be used. Individual confidentiality is protected by the use of assigned code numbers, and by reporting only the group results.

I understand that should I have any questions about my participation in this study, or any other relevant matter, I may call the Co-Investigator (Ester Rabinowicz (212)960-2472(3), or Director of the Unit (Dr. Lewis A. Opler, 212-305-4575), and I will be given an opportunity to discuss in confidence any questions I may have with them. If I have any questions about my rights as a research subject or any complaints, I may call the New York State Psychiatric Institute-Columbia University Department of Psychiatry Institutional Review Board Office at 212-960-5758.

Perceptual Organization in Schizophrenia (PIRB Protocol #1784)

Informed Consent Form For Patients

Principal Investigator: Dr. Lewis A. Opler-Tele. No:(212) 305-4575

I have been given a copy of the consent form to keep.

The New York State Psychiatric Institute-Columbia University Department of Psychiatry Institutional Review Board (212-960-5758) has approved the recruitment of subjects for this study.

I have read the above and I am presently willing to participate in this study.

Name of Participant:______________________________

Signature of Participant:________________ Date:________

C.U. DEPT OF PSYCHIATRY I.R.B. NEW YORK STATE
PROTOCOL # 1784
CONSENT FORM
APPROVED UNTIL
1/90
MONTH YEAR

Perceptual Organization in Schizophrenia (PIRB Protocol #1784)

Informed Consent Form For Patients

Principal Investigator: Dr. Lewis A. Opler-Tele. No:(212) 305-4575

1.Inpatients from vulnerable populations

A)I examined this patient on _______for the purpose of determining whether he/she is capable of understanding the risks and benefits of the research and consenting to his/her participation in the research protocol listed above. On the basis of my examination, I have arrived at the conclusion that (check one)

_____1)This patient has this capacity at this time

_____2)There is a question about this patient's capacity at this time

_____3)This patient clearly lacks this capacity

DATE____________________ Signature__________________________
Member of Research Team

DATE____________________ Signature__________________________
Member of Treatment Team

B)Medical Record Review

I have reviewed this patient's medical record at Presbyterian Hospital for three months (or less if patient in treatment for less than three months) and:

(check one)

_____1)The medical record is consistent with the judgment made above about this patient's capacity.

_____2)There are notations in this patient's records suggesting a lack of capacity, in contrast to the judgment made above. My reasons for disagreeing with the chart notation(s) are documented below:

DATE_____ Signature__________________________
Member of Research Team

Perceptual Organization in Schizophrenia (PIRB Protocol #1784)

Informed Consent Form For Patients

Principal Investigator: Dr. Lewis A. Opler-Tele. No:(212) 305-4575

C)Family and Friends

I have discussed with this patient our wish to inform a family member or friend about this research, and:

(check all that apply)

_____1)This patient asked that the following person be notified:

(Name)______________________________

_____a)The person named above was notified

_____b)Unsuccessful attempts were made to notify the person named above

_____2)This patient does not wish that any family member or friend be notified.

DATE______________ Signature____________________
Member of Research Team

2.Patients Who Lack Capacity

A)This patient does not object to participation in this protocol.

DATE______________ Signature______________________
Member of Research Team Who Obtains Consent

B)Although this patient lacks capacity, since the IRB has determined that this protocol involves no more than minimal discomfort and/or other risks, and will potentially produce significant information about a condition presented by the patient, and the research could not be done without involving incapable subjects, this protocol is approved for this patient.

DATE______________ Signature______________________
Deputy Director, NYSPI

DATE______________ Signature______________________
Spouse, Parent, Adult
Child, Guardian, or Court of Competent
Jurisdiction

Perceptual Organization in Schizophrenia (PIRB Protocol #1784)

Informed Consent Form For Patients

Principal Investigator: Dr. Lewis A. Opler-Tele. No: (212) 305-4575

3.Patients for whom there is a doubt about capacity

A)Because some question has been raised about this patient's capacity, I have examined this patient on _____and my opinion about his/her capacity is summarized below:

DATE_______________ Signature___________________________
Independent Consultant

B)I have reviewed the opinion of the consultant summarized above, and it is my judgment that this patient (_____does _____does not) have capacity to understand the benefits and risks of this protocol, and my reasons are outlined below:

DATE_______________ Signature___________________________
Deputy Director, NYSPI

New York State Psychiatric Institute-Columbia University Department of Psychiatry P. 1 of 2

INFORMED CONSENT FORM FOR CONTROL SUBJECTS -

FAMILY MEMBERS AND RELATIVES OF INPATIENTS ON PI-4

Perceptual Organization in Schizophrenia (PI IRB #1784

Principal Investigator:Dr. Lewis A. Opler (212) 305-4575

Co-Investigators: Esther Rabinowicz (212) 960-2472(3)
Dr. J. Gibbon (212)960-2472(3)

PROTOCOL # 1784
CONSENT FORM
APPROVED UNTIL
0/92
MONTH - YEAR
I.R.B. SIGNATURE
N.Y.C. DEPT OF PSYCHIATRY I.R.B. NEW YORK STATE PSYCHIATRIC INSTITUTE

Name of Participant:________________________________

Purpose of Study: The purpose of this study is to understand more about the relationship between mental processes and psychiatric symptoms. Specifically, I have been asked to participate in this research to study how individuals like myself and psychiatric patients respond to visual stimuli.

Description of Study Procedures: This study consists of two parts - a diagnostic interview and a visual task. In the first part, I will be interviewed about my health, social factors and emotional states. I will be asked to voluntarily answer a number of questions about how I feel and about any emotional problems I may have had in the past. The length of this interview will be about one hour.

If I am eligible and if I choose to continue to participate, I will do the visual task. In this task, I will be seated in front of a computer (video) screen, on which dots will be briefly flashed. I will be asked to remember and report certain information about the visual display, such as the number of dots I saw flashing.

The total time of the study, including interviewing and testing, will take about 2 hours. If I wish, I will be given short breaks. I may withdraw from the testing at any time.

Expected Risks and Benefits: There are no known risks involved in this study. None of the procedures are hazardous or invasive. There are no foreseeable medical or psychological risks.

I know that these studies are being done for research purposes and that I probably will not benefit directly. However, the knowledge gained through my participation may provide future benefits for individuals with mental health problem in terms of improved understanding, diagnosis and treatment.

Compensation
I will be compensated for my participation in this study, and after completion of the testing session I will be paid $10.00 per hour. If I decide to withdraw, payment will be prorated for the length of time that I participated.

Perceptual Organization in Schizophrenia (PIRB #1784)

Informed Consent Form For Control Subjects

Principal Investigator: Dr. Lewis A. Opler (212) 305-4575

Co-Investigators: Esther Rabinowicz (212) 960-2472(3)
Dr. J. Gibbon (212) 960-2473(3)

C.U. DEPT. OF PSYCHIATRY I.R.B. NEW YORK STATE PSYCHIATRIC INSTITUTE
PROTOCOL #1784
CONSENT FORM APPROVED UNTIL 2/92
MONTH - YEAR
I.R.B. SIGNATURE

Research Standards and Rights of Participants: The nature of this study has been clearly explained to me both in writing and verbally. I understand that my participation in this study is strictly voluntary. I have the right to refuse to participate in, or to withdraw from this study at any time should I choose to participate; without loss of any benefits to which I am otherwise entitled, and without prejudicing in any way the health care of my relative(s).

I understand that my right to privacy and the confidentiality of my participation in this project, should I choose to participate, will be safeguarded. All information obtained in this study will be kept in a locked office and wil be available only to the responsible researchers, or to some state regulatory personnel as part of a routine audit. When the research findings are published or presented, no individual identifying information will be used. Individual confidentiality is protected by the use of assigned code numbers, and by reporting only the group results.

I understand that should I have any questions about my participation in this study, or any other relevant matter, I may call the Co-Investigator (Esther Rabinowicz at (212)960-2472(3), or the Director of the Unit (Dr. Lewis A. Opler, 212-305-4575); and I will be given an opportunity to discuss in confidence any questions I may have with them. If I have any questions about my rights as a research subject or any complaints, I may call the New York State Psychiatric Institute-Columbia University Department of Psychiatry Institutional Review Board Office at (212)-960-5758.

I have been given a copy of the consent form to keep.

The New York State Psychiatric Institute-Columbia University Department of Psychiatry Institutional Review Board (212) 960-5758 has approved the recruitment of subject for this study.

I have read the above and I am presently willing to participate in this study.

Name of Participant:________________________________

Signature of Participant:__________________Date:__________________

New York State Psychiatric Institute-Columbia University Department of Psychiatry P. 1 of 4

INFORMED CONSENT FORM FOR PATIENTS ON PI-4

Perceptual Organization in Schizophrenia (PIRB Protocol #1784)

Principal Investigator: Dr. Lewis A. Opler (212)305-4575

Co-Investigators: Esther Rabinowicz (212) 960-2472(3)
Dr. J. Gibbon (212) 960-2472(3)

C.U. DEPT OF PSYCHIATRY I.R.B. NEW YORK STATE PSYCHIATRIC INSTITUTE
PROTOCOL # 1784
CONSENT FORM APPROVED UNTIL
MONTH - YEAR
I.R.B. SIGNATURE

Name of Participant:__________________________________

Purpose of Study: The purpose of this study is to understand about the relationship between mental processes and psychiatric symptoms. Specifically, I have been asked to participate in this research to study how patients like myself and other individuals respond to visual stimuli.

Description of Study Procedures: If I choose to participate, I will be seated in front of a computer (video)screen, on which dots will be briefly flashed. I will be asked to remember and report certain information about the visual display, such as the number of dots I saw flashing.

If my doctor feels it is alright for me, I will leave the ward on an accompanied pass to PI-6 South, to the unit where testing will take place. For patients who cannot be escorted off the unit, testing may take place on the unit (i.e. PI-4).

The total time of the study, including practice and testing, will take between 1 and 2 hours. I will be given several short breaks (2 minutes each), and one longer break (10 minutes) during the test session. If I feel tired, upset, or don't wish to continue, I may withdraw from the testing at any time. If I am unable to complete the testing in one session, and if I wish, I may complete it in two sessions.

Expected Risk and Benefits: There are no known risks involved in this study. None of the procedures are hazardous or invasive. There are no foreseeable medical or psychological risks. If, however, I feel fatigued, uncomfortable, or in any way upset during any part of the study; I may ask for a rest break or to discontinue the study.

I know that these studies are being done for research purposes and I probably will not benefit directly. However, the knowledge gained through my participation may provide future benefits for individuals with mental health problem in terms of improved understanding, diagnosis and treatment. In addition, because this study involves a video screen, it may provide some fun and a change in the routine of the ward.

Perceptual Organization in Schizophrenia (PIRB Protocol #1784)

Informed Consent Form For Patients

Principal Investigator: Dr. Lewis A. Opler (212)305-4575

Co-Investigators: Esther Rabinowicz (212)960-2472(3)
Dr. J. Gibbon (212)960-2472(3)

Research Standards and Rights of Participants: The nature of this study has been clearly explained to me both in writing and verbally. I understand that my participation in this study is strictly voluntary. I have the right to refuse to participate in, or to withdraw from this study at any time should I choose to participate; without my treatment being withheld or changed in any way. I have the right to withdraw from this experiment at any time, if I do choose to participate. I understand that whether I participate or not in this research, will not affect my regular clinical care, or any future clinical care, at either Presbyterian Hospital or at New York State Psychiatric Institute.

I understand that my right to privacy and the confidentiality of my participation in this project, should I choose to participate, will be safeguarded. All information obtained in this study will be kept in a locked office and will be available only to the responsible researchers, or to some state regulatory personnel as part of a routine audit. When the research findings are published or presented, no individual identifying information will be used. Individual confidentiality is protected by the use of assigned code numbers, and by reporting only the group results.

I understand that should I have any questions about my participation in this study, or any other relevant matter, I may call the Co-Investigator Esther Rabinowicz (212)960-2472(3), or Director of the Unit (Dr. Lewis A. Opler, (212)305-4575), and I will be given an opportunity to discuss in confidence any questions I may have with them. If I have any questions about my rights as a research subject or any complaints, I may call the New York State Psychiatric Institute-Columbia University Department of Psychiatry Institutional Review Board Office at (212)960-5758.

CU. DEPT OF PSYCHIATRY I.R.B. NEW YORK STATE PSYCHIATRIC INSTITUTE
PROTOCOL # 1784
CONSENT FORM APPROVED UNTIL
2/92
MONTH YEAR
I.R.B. SIGNATURE

Perceptual Organization in Schizophrenia (PIRB Protocol #1784)

Informed Consent Form For Patients

Principal Investigator: Dr. Lewis A. Opler (212)305-4575

Co-Investigators: Esther Rabinowicz (212)960-2472(3)
Dr. J. Gibbon (212) 960-2472(3)

I have been given a copy of the consent form to keep.

The New York State Psychiatric Institute-Columbia University Department of Psychiatry Institutional Review Board (212-960-5758) has approved the recruitment of subjects for this study.

I have read the above and I am presently willing to participate in this study.

Name of Participant:____________________________

Signature of Participant:____________________ Date:______

C.U. DEPT OF PSYCHIATRY I.R.B. NEW YORK STATE PSYCHIATRIC INSTITUTE
PROTOCOL # 1784
CONSENT FORM
APPROVED UNTIL
2/92
MONTH YEAR
I.R.B. SIGNATURE

Perceptual Organization in Schizophrenia (PIRB Protocol #1784)

Informed Consent Form For Patients

Principal Investigator: Dr. Lewis A. Opler (212) 305-4575

Co-Investigators: Esther Rabinowicz (212) 960-2472(3)
Dr. J. Gibbon (212) 960-2472(3)

1.Inpatients from vulnerable populations

I have discussed the proposed research with this patient and, in my opinion, this patient understands the benefits and risks and is capable of freely consenting to participate in this research.

DATE ______________ SIGNATURE ____________________________
Study Physician

I have examined ______________________ on ______________ for the purpose of determining whether he/she is capable of understanding the purpose, nature, risks, benefits and alternatives (including non-participation) of the research, making a decision about participation, and understanding that the decision about participation in the research will involve no penalty or loss of benefits to which the patient is otherwise entitled, for Dr. _________________'s research project ______________________. On the basis of this examination I have arrived at the conclusion that:

_____A)This patient has this capacity at this time

_____B)There is a question about this patient's capacity at this time

_____C)This patient clearly lacks this capacity

DATE________________ Signature______________________
Member of Treatment Team
(M.D. or Ph.D.)

C.U. DEPT OF PSYCHIATRY I.R.B. NEW YORK STATE PSYCHIATRIC INSTITUTE
PROTOCOL # 1784
CONSENT FORM
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I.R.B. SIGNATURE

APPENDIX B

Stimuli Prototypes and Sample Stimuli

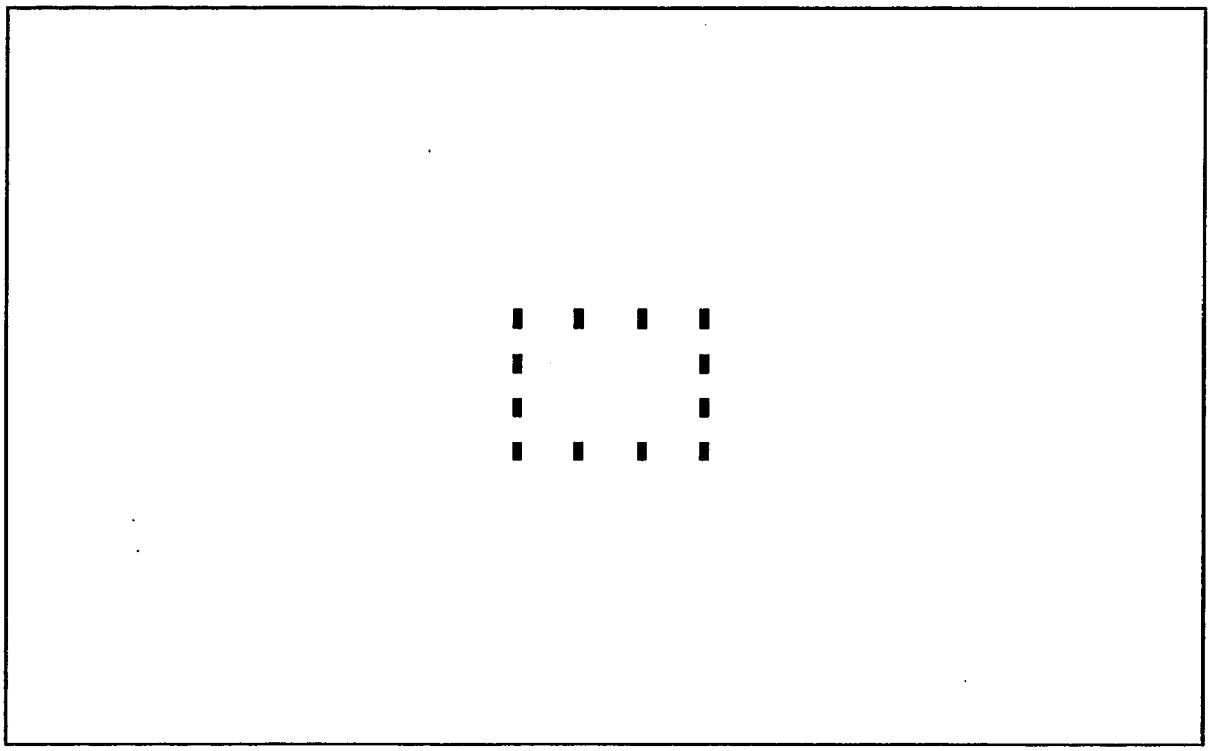

Figure 11. Prototype for square stimuli.

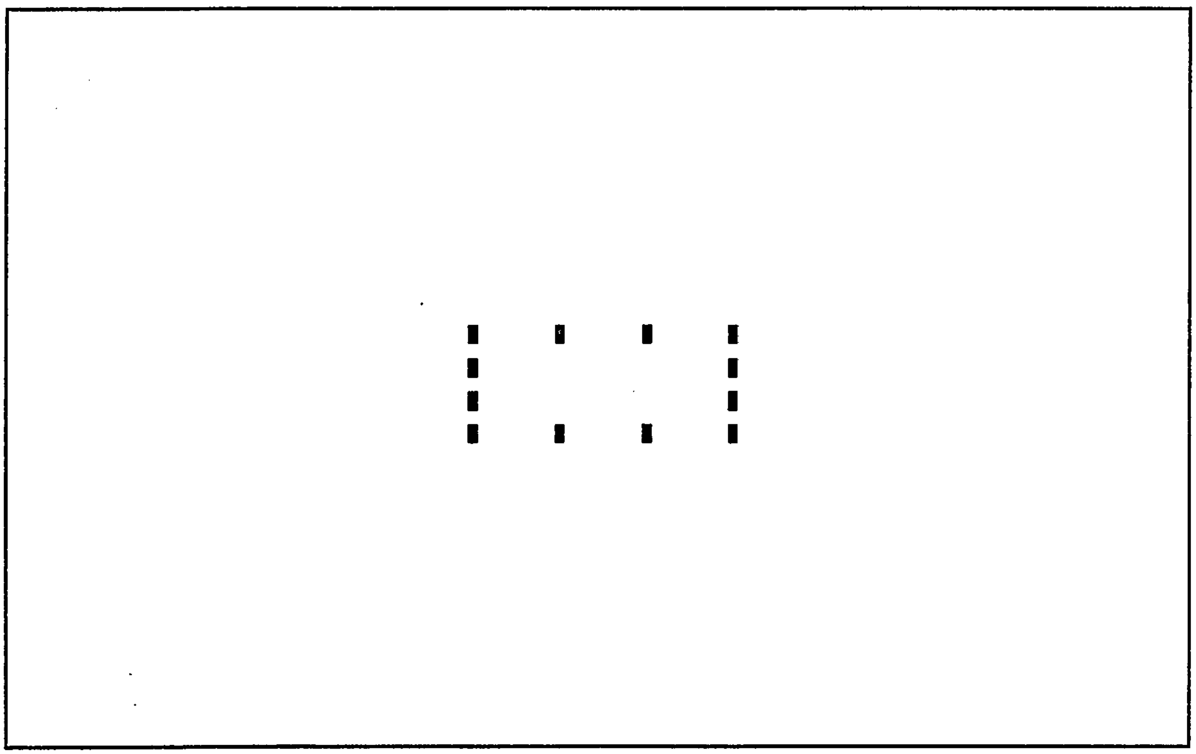

Figure 12. Prototype for horizontal rectangular stimuli.

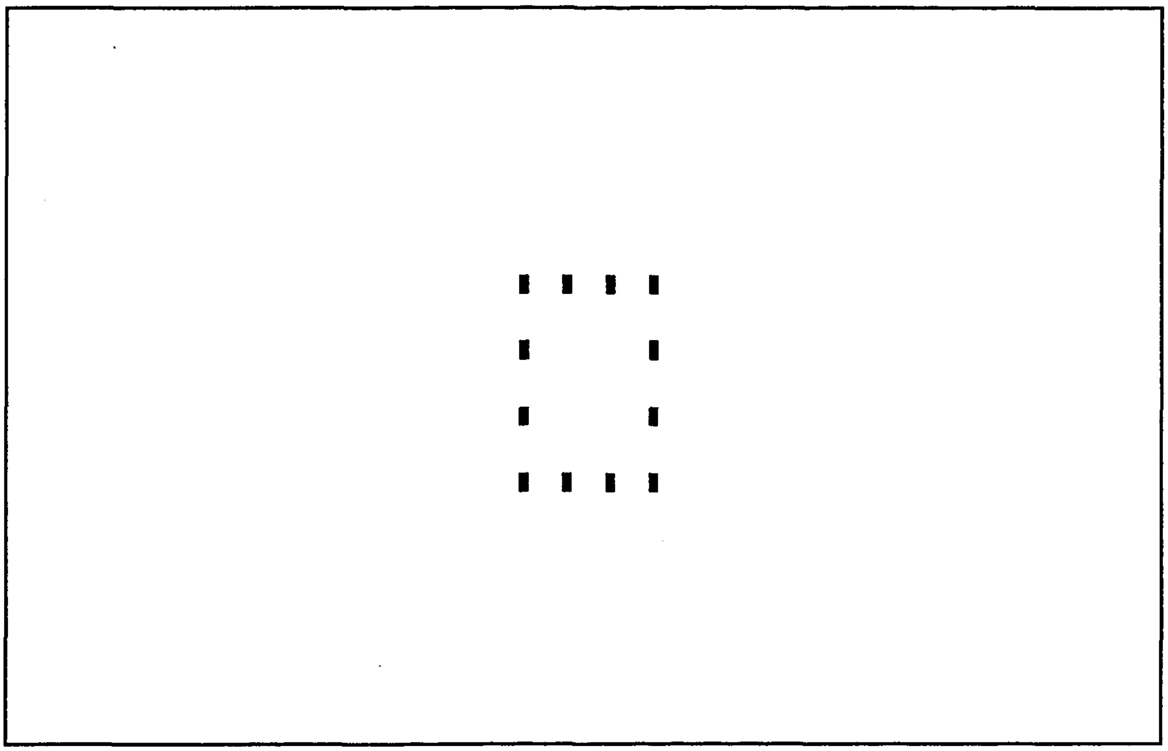

Figure 13. Prototype for vertical rectangular stimuli.

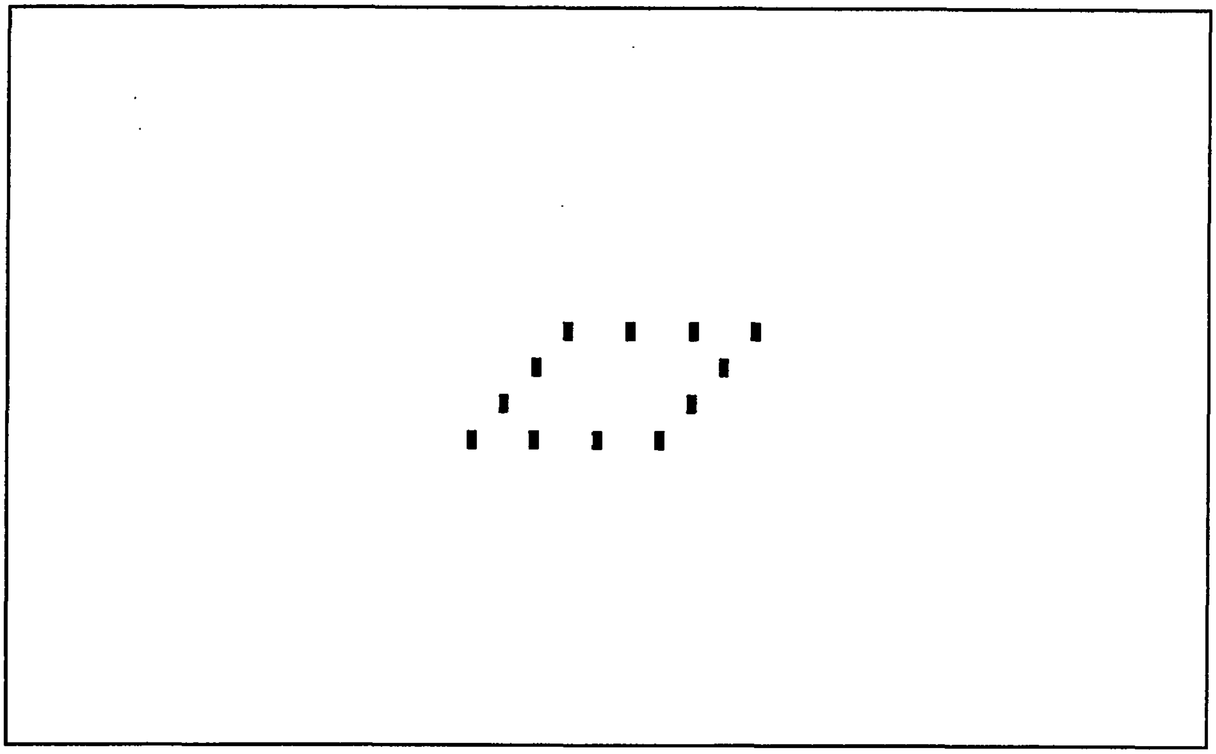

Figure 14. Prototype for right-leaning rhombic stimuli.

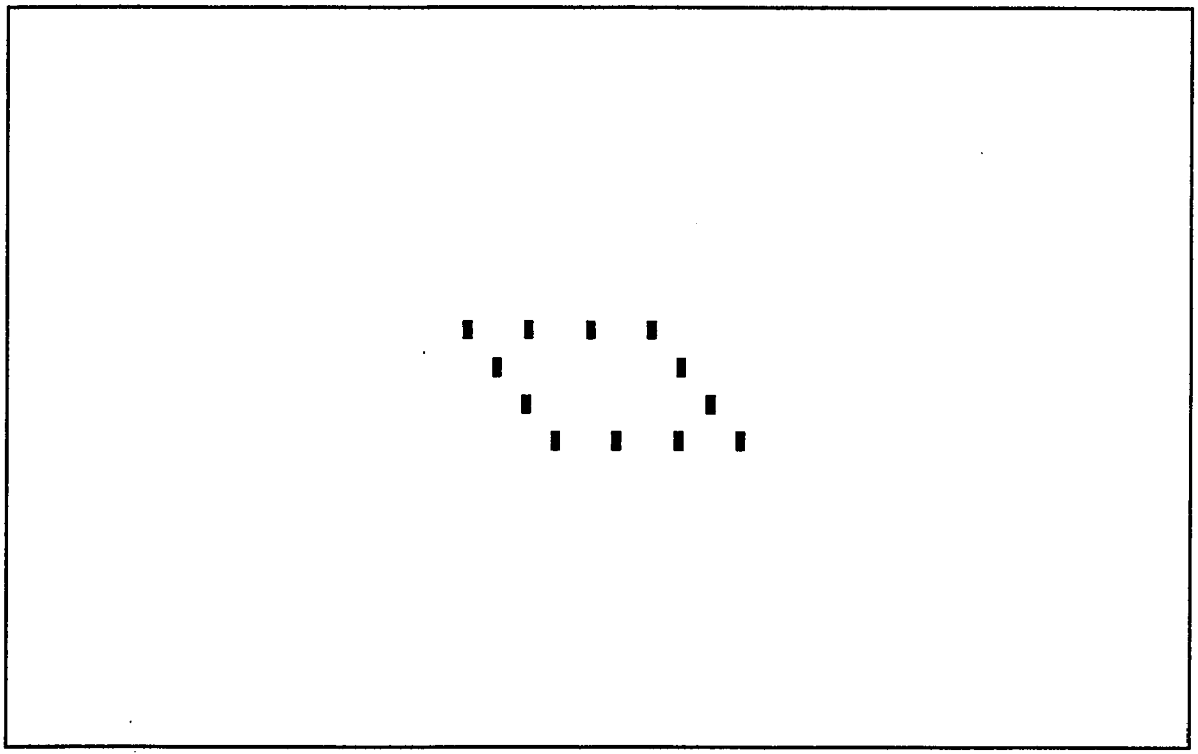

Figure 15. Prototype for left-leaning rhombic stimuli.

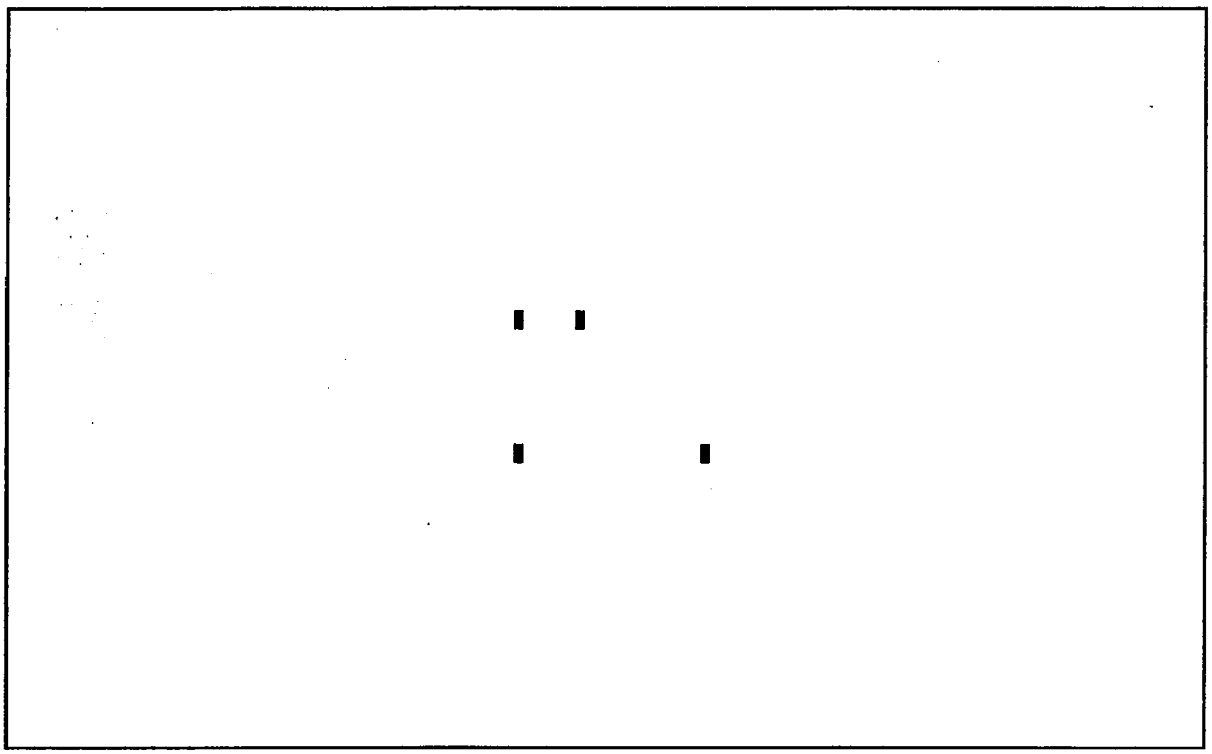

Figure 16. Example of a four-dot square stimulus.

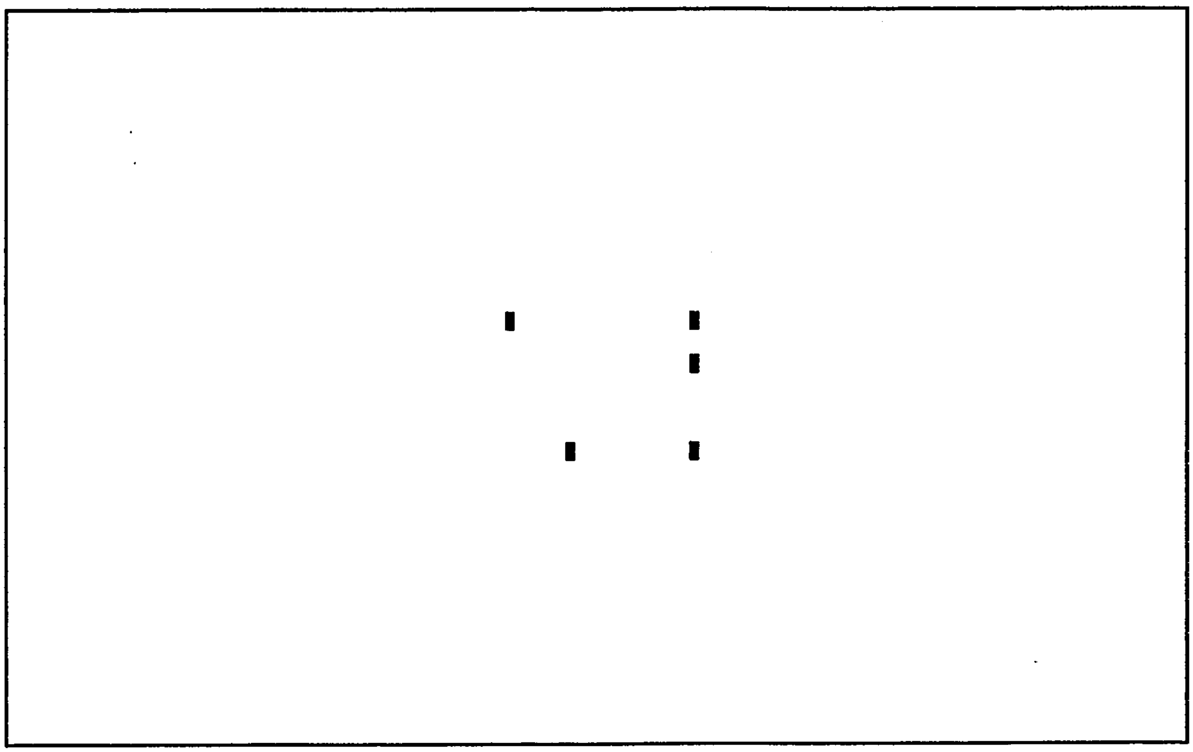

Figure 17. Example of a five-dot square stimulus.

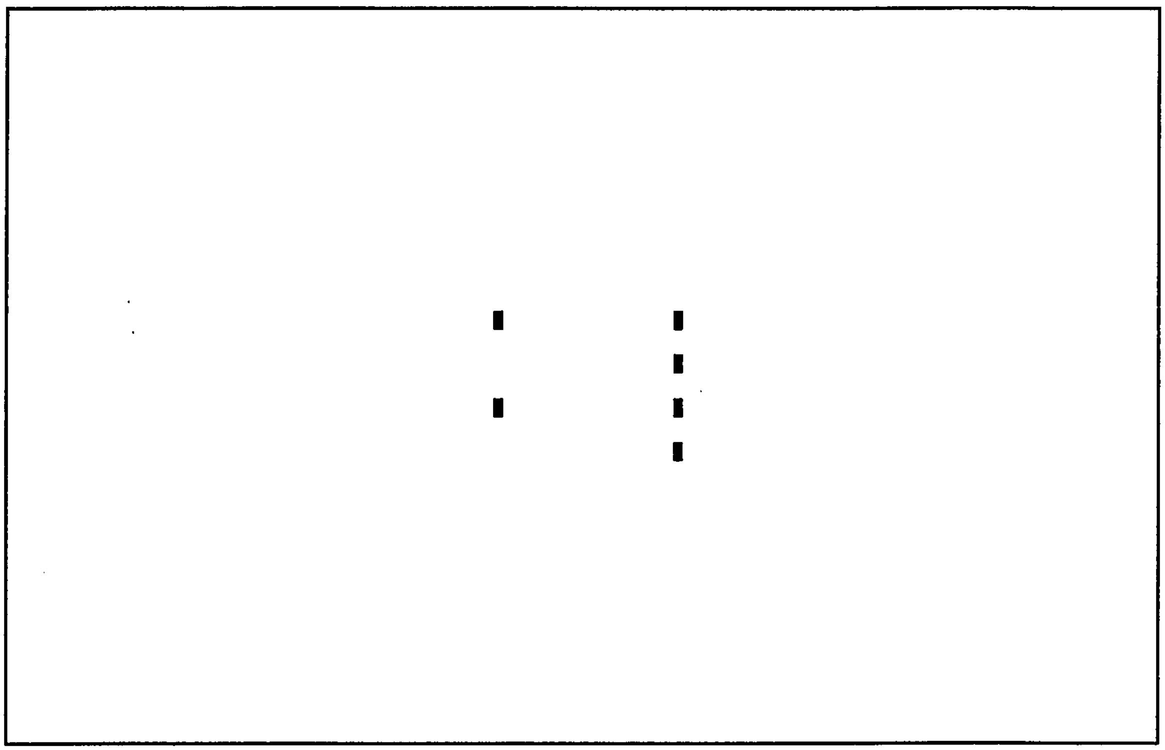

Figure 18. Example of a six-dot square stimulus.

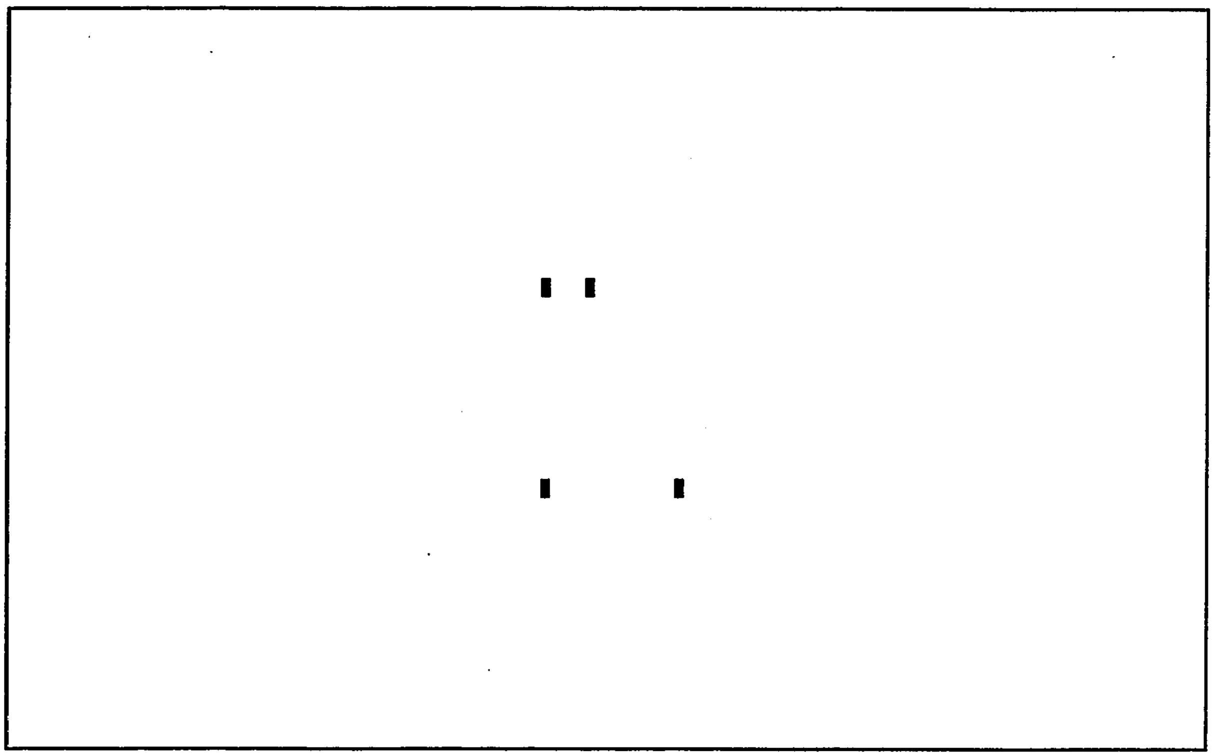

Figure 19. Example of a four-dot rectangular stimulus.

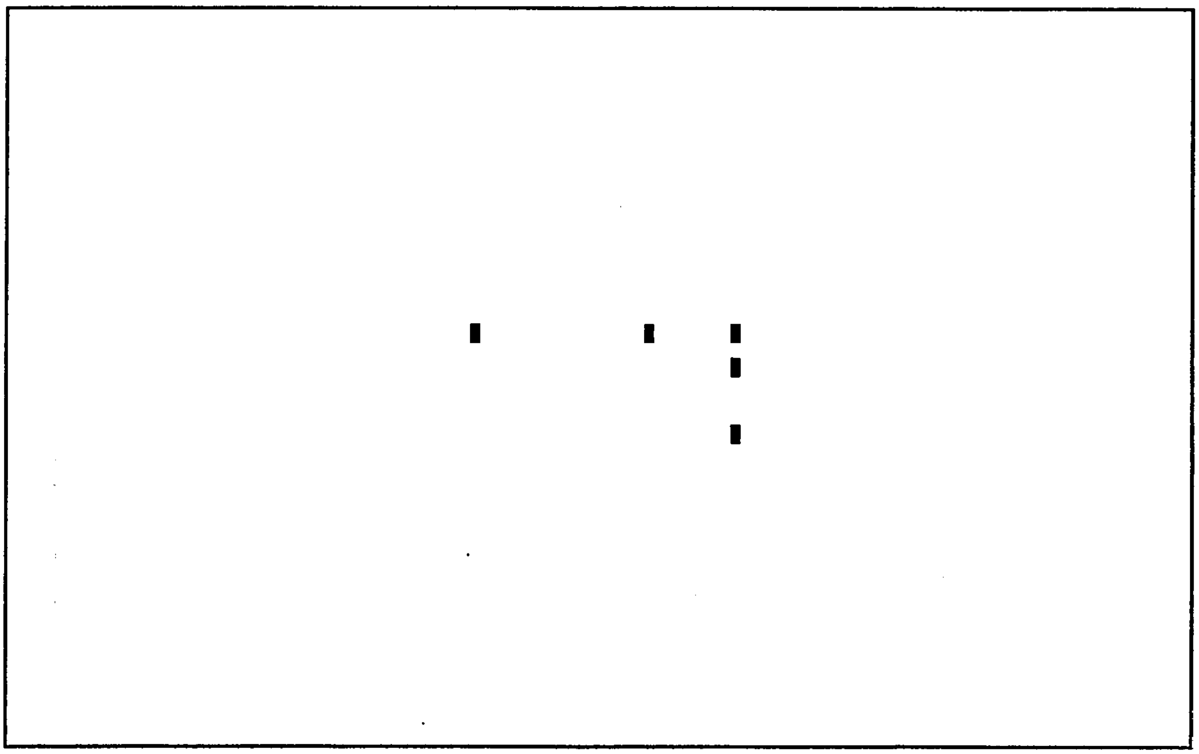

Figure 20. Example of a five-dot rectangular stimulus.

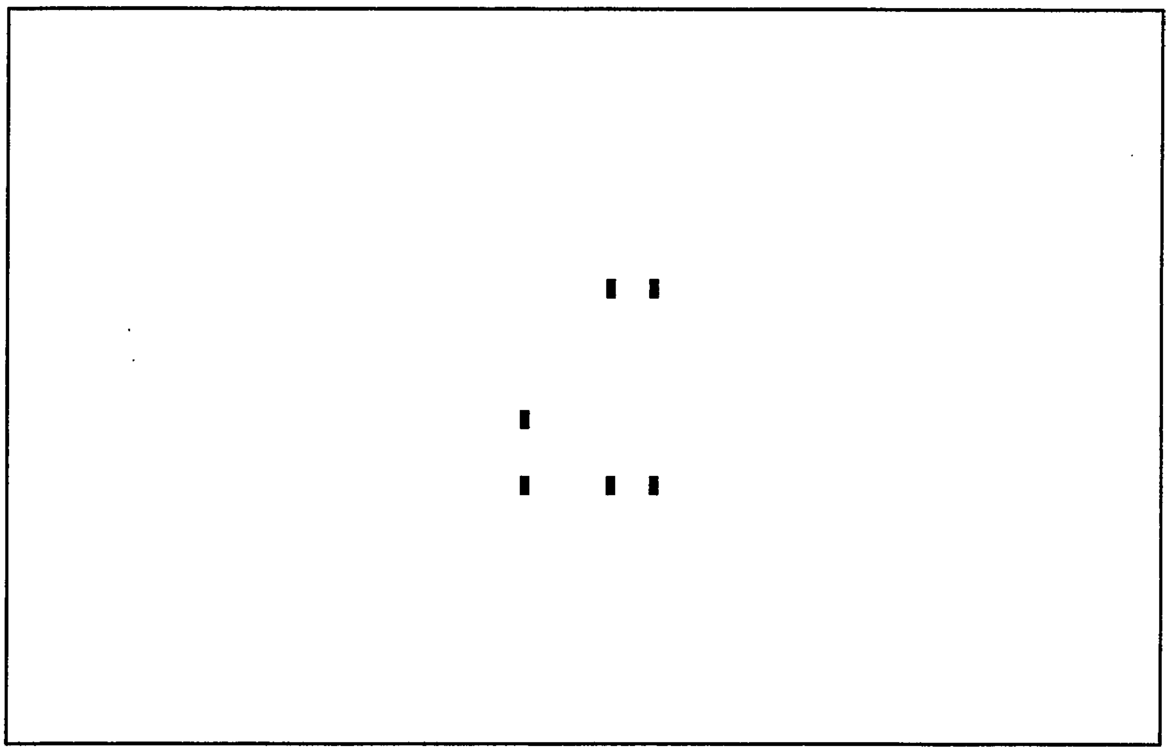

Figure 21. Example of a six-dot rectangular stimulus.

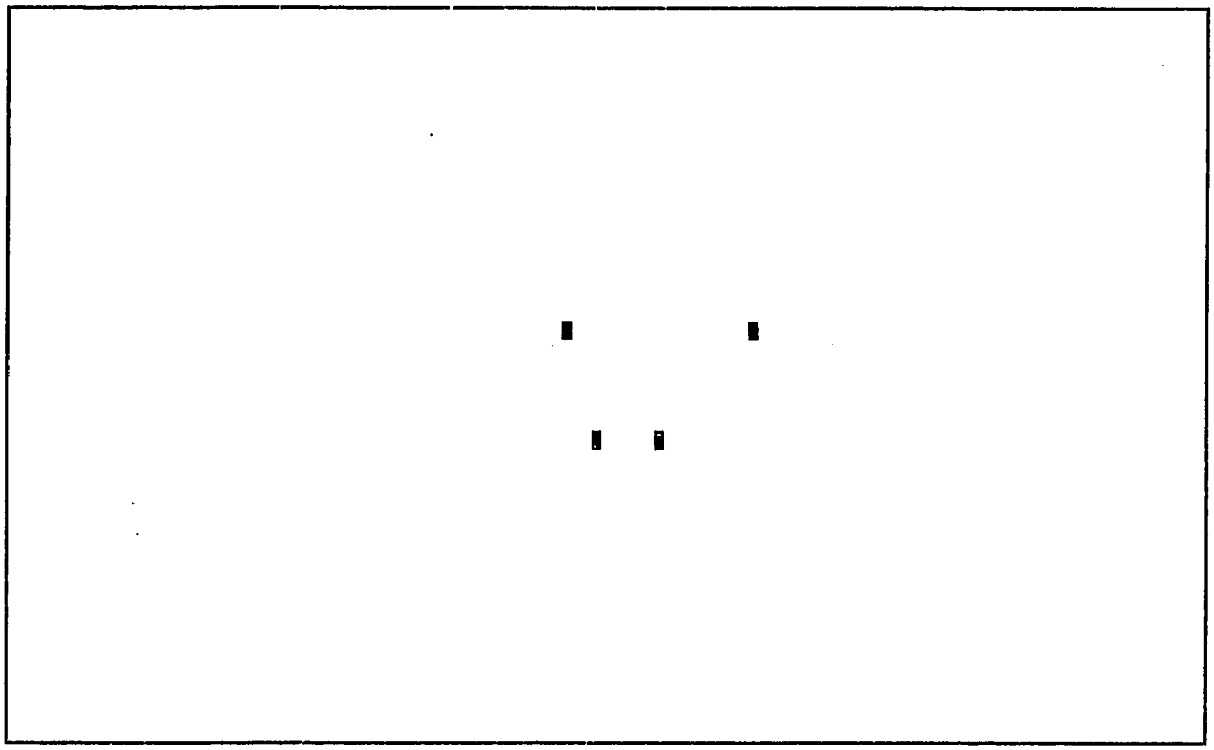

Figure 22. Example of a four-dot rhombic stimulus.

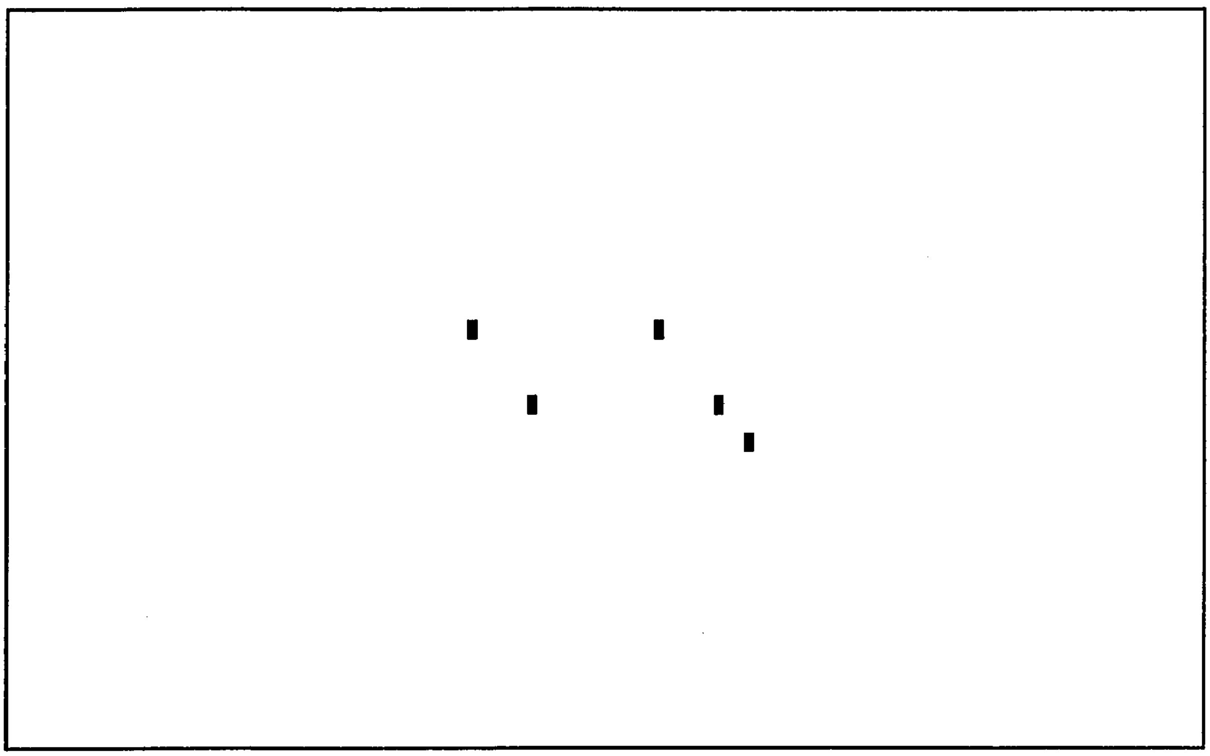

Figure 23. Example of a five-dot rhombic stimulus.

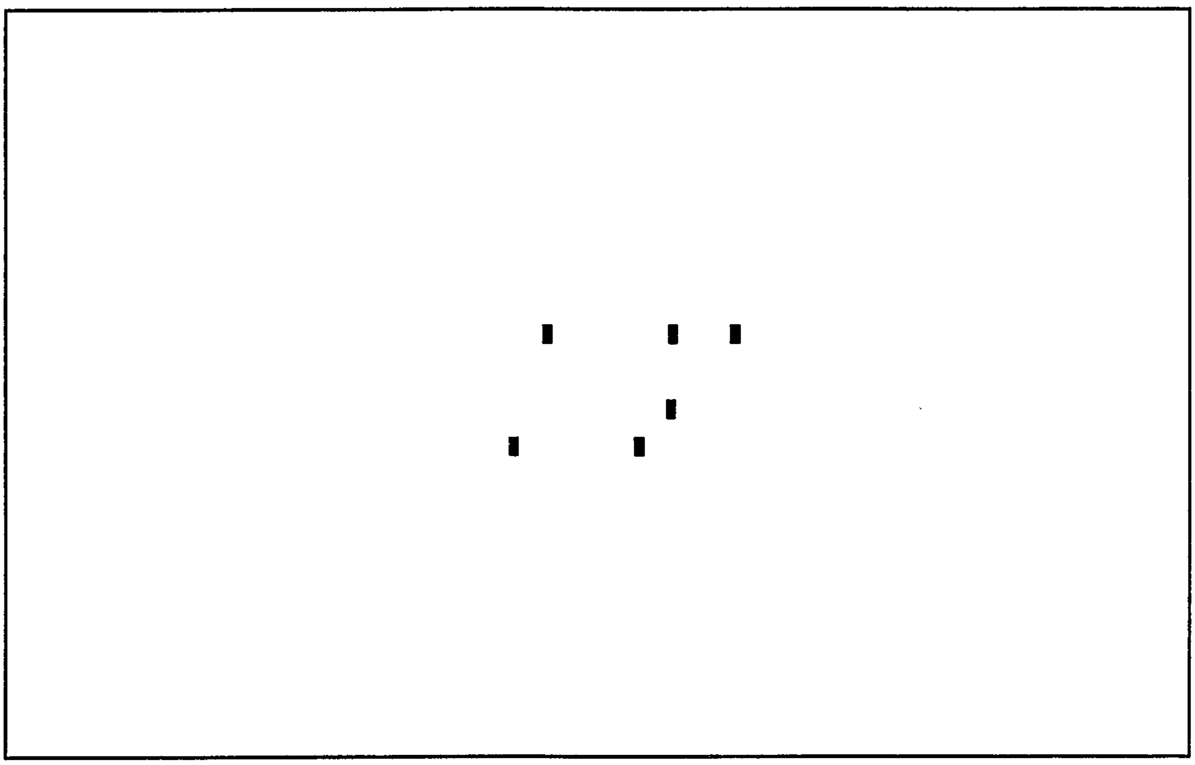

Figure 24. Example of a six-dot rhombic stimulus.

APPENDIX C

Instructions for Subjects

INSTRUCTIONS FOR THE NUMBER CONDITION

You will see stimuli flashing on the computer screen. Each trial begins with a tone and a fixation dot. This means get ready for the stimulus. Each stimulus pattern will be made up of either 4, 5, or 6 points (dots). Your task is to count the number of dots quickly and accurately. Indicate your choice by pressing either the 4, 5, or 6 key. After the stimulus flashes, you will hear a beep. You may only respond *after* this beep sounds. Remember, wait for the beep, and then press the appropriate key answering the question, "How many points did you see?"

Are there any questions?

INSTRUCTIONS FOR THE FORM PRACTICE SESSION

You will be shown stimuli flashing on a computer screen. Each stimulus pattern will be one of three geometric forms. The forms are all four-sided figures and are called *square*, *rectangle*, or *rhombus*. The square has four equal sides and four right angles (i.e., 90°); the rectangle has two pairs of opposite sides that are equal, and four right angles; and the rhombus has four equal sides and oblique angles (i.e., angles greater or less than 90°). At least 3 corners will always be defined by dots. Each trial begins with a tone and a fixation dot. This means get ready for the stimulus. Your task is to say quickly and accurately the geometric form that you see. After the stimulus flashes you will hear a beep. You may only respond *after* this beep sounds. Remember, wait for the beep, and then answer the question, "Which form did you see?".

Press 4 for square, 5 for rectangle, and 6 for rhombus to indicate your choice.

Are there any questions?

INSTRUCTIONS FOR THE FORM EXPERIMENTAL SESSION

You will see stimuli flashing on the computer screen. Each trial begins with a tone and a fixation dot. This means get ready for the stimulus. Each stimulus pattern will be either a *square*, *rectangle*, or *rhombus* with at least 3 corners defined by dots. Your task in this condition is to respond quickly and accurately to the geometric form that you see. Indicate your choice by pressing either the square, rectangle or rhombus key*. After the stimulus flashes you will hear a beep. You may only respond *after* this beep sounds. Remember, wait for the beep, and then press the appropriate key answering the question, "Which form did you see?"

Press 4 for square, 5 for rectangle, and 6 for rhombus.

Are there any questions?

APPENDIX D

Presentation Frequencies Per Cell for Each Condition

Table 10

Presentation Frequencies Per Cell for Both the Number and Form Conditions

Delay	Shape								
	Square			Rectangle			Rhombus		
	Points			Points			Points		
	4	5	6	4	5	6	4	5	6
0 s	3	7	5	8	4	9	6	10	8
2 s	4	10	6	4	6	9	6	7	8
4 s	3	7	5	8	8	8	6	9	6

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Asarnow, R. F., & MacCrimmon, D. J. (1978). Residual performance deficit in clinically remitted schizophrenics: A marker of schizophrenia? *Journal of Abnormal Psychology, 87*, 597-608.

Asarnow, R. F., & MacCrimmon, D. J. (1981). Span of apprehension deficits during the post-psychotic stages of schizophrenia: A replication and extension. *Archives of General Psychiatry, 38*, 1006-1011.

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