The problem with actually specifying what one is measuring and the mechanisms responsible for differences found between non-patient and psychiatric populations extends even to measurements of sensory and of perceptual thresholds. In a large number of earlier studies, the threshold of psychiatric patients had been found to differ significantly from those of control groups across a variety of sensory and perceptual tasks (see Granger, 1953, 1957). Some investigators suggested that abnormal thresholds in psychiatric patients may reflect subtle physiological changes in the brain (Landis, 1951; Landis & Clausen, 1955; Burdock, Sutton & Zubin, 1958), while others suggested that seemingly elevated thresholds (especially flicker fusion thresholds in vision) were due to non-sensory factors such as a cautious attitude (e.g., Wagoner, 1960). Using an experimental design based on statistical decision theory (theory of signal detection), Clark, Brown & Rutschmann (1967) reported that the differences in flicker-fusion threshold between psychiatric patients and control subjects found with traditional psychophysical procedures can be attributed to differences in response bias rather than to differences in sensory function. They also concluded that the forced-choice procedure has a higher inferred validity for the study of psychiatric patients than either the traditional method of limits or the method of constant stimuli.

In the present study, we use a three alternative temporal forced-choice technique to measure monaural temporal interactions in psychiatric patient and non-patient populations. This technique eliminates the response bias or criterion problem since the subject must choose between alternative intervals and a conservative or lax criterion cannot operate to bias the results.
The three alternative temporal forced choice technique also has the advantage that the subject may respond based only on his perception of a difference in one of the three intervals. He need not be dependent on his memory of the signal from previous trials, as is the case, for example, in "Yes-No" and two-interval forced choice tasks. This may reduce the influence of a non-sensory memory factor on performance (Sutton, 1973).

The next two sections introduce the psychophysical paradigm we use to measure monaural temporal interactions and the application of that paradigm to the study of temporal processing in psychiatric patients.

Monaural Temporal Interaction

When two monaurally presented auditory stimuli are separated by short temporal intervals certain perceptual phenomena result. If the two transient stimuli are unequal in intensity and separated by 3 msec., or less, depending upon the ratio of intensities ($\Delta I$) and their temporal order (i.e., whether the more intense stimulus leads or follows the less intense one), the two stimuli cannot be discriminated from a single stimulus which is equal in level to the more intense member of the pair. This phenomenon is usually referred to as "masking". If the more intense stimulus leads the less intense one, this is referred to as "forward" masking; whereas, if the less intense stimulus leads the more intense one, this is referred to as "backward" masking. Which paradigm results in more masking depends upon the type of stimuli involved (transient or pure tones) and the frequency content of the stimuli (Christovich & Ivanova, 1959; Elliot, 1962a & b; Goldburt, 1961; Raab, 1961; Samoliov, 1956, 1959; Wright, 1964; Babkoff & Sutton, 1968, 1971). As the temporal interval separating the pair of transients is increased to approximately 5 or 10 msec., depending upon the ratio of
intensities and their temporal order, the pair is easily discriminated as different from the more intense transient alone, but a subject is unable to discriminate the temporal order of the pair of transients, i.e., whether the more intense stimulus leads or follows the less intense one. When the stimulus separations are longer than about 20 msec, the order of stimulus presentation can generally be discriminated (Hirsch & Sherrick, 1961; Babkoff & Sutton, 1963; Thor, 1968).

We have recently made several modifications of this basic psychoacoustic procedure. The first modification consists of varying the interpulse interval (Δt) as the independent variable in the measurement of masking, while maintaining the level of both the masking and the test, or probe, stimulus constant. The second modification consists of using a "mirror image" paradigm in which the subject is required to discriminate a pair of monotonic transients in the backward masking mode (less intense first) from its mirror image in the forward masking mode (more intense first). The backward masking pair is the test stimulus, while two identical forward masking pairs are comparison stimuli in a three-alternative temporal forced-choice design. With these modifications we have been able to find monaural temporal interactions which extend much further than the 3 msec value we reported for monaural temporal masking in our 1968 paper, and which cannot be accounted for by a model involving primarily peripheral mechanisms but must also involve central nervous system processes.

In a recent publication (Babkoff & Sutton, 1971), we reported data which indicated that the interaction between members of pulse pairs of unequal intensity extends into a Δt region in which masking in the "formal" sense is no longer evident and the extent of this interaction is a function of the
interpulse ratio ($\Delta I$). These data are consistent with the hypothesis that spatiotemporal patterns of neural activity evoked by both the more intense and less intense members of the pulse pair are present in the nervous system even at very short interpulse intervals. The means by which sensory information is processed in time allows for interaction within the sensory channel of the neural correlates of both members of the pulse pair. It is the nature of this interaction which gives rise to discrimination phenomena at intermediate interpulse intervals (from about 3 msec to 10 or 20 msec); interaction which was only revealed by the "mirror image" discrimination paradigm. The discrimination functions obtained using this paradigm show an initial rise in accuracy as $\Delta t$ increases followed by an asymptote, i.e., a leveling at a high discrimination level, followed by a decrease in accuracy in the intermediate $\Delta t$ range (from about 3 or 8 msec to 10 or 20 msec) followed finally by a second rise in accuracy as $\Delta t$ is increased beyond about 20 msec. The effect of increasing the interpulse ratio ($\Delta I$) is to displace the entire discrimination function into a longer $\Delta t$ range.

What is the nature of the interaction that extends from about 3 msec to approximately 10 or 20 msec? Since the $\Delta t$ range within which the interaction is evident is shorter than 20 msec, it appeared only reasonable to conclude, on the basis of the literature, that subjects are unable to perceive the temporal order of the stimuli (i.e., whether the less intense stimulus precedes or succeeds the more intense stimulus) in this $\Delta t$ range. The nonmonotonic shape of the function also supports this contention since the discrimination of temporal order, when it is not dependent upon some complex interaction of the two stimuli whose order is to be perceived, is a monotonic function of interpulse interval (Hirsch, 1959;
Hirsch & Sherrick, 1961; Babcock & Sutton, 1963; Rutschmann, 1966; Thor, 1968; Homick, Elemer & Bothe, 1969). The decrease in accuracy as \( \Delta t \) is increased in the intermediate \( \Delta t \) range suggests that in this \( \Delta t \) region the temporal order cue is not yet available. Rather, it is the difference in interaction between the two masking modes that generates different perceptual cues which result in discrimination. Since this interaction decreases with increases in \( \Delta t \), there is a decrease in the accuracy of discrimination. However, increasing \( \Delta t \) beyond this intermediate range results in an increase in accuracy because the temporal order of the stimuli begins to be perceived.

In summary, the experiments reported in Babcock & Sutton (1971) lend support to the concept that masking does not involve merely the decrement in auditory sensitivity caused by intense stimulation. Rather, the data lend support to the hypothesis that interaction exists between the more intense and less intense members of the pulse pair even when masking in the formal sense is no longer evident. The ability to discriminate between the forward and backward masking modes at the intermediate interpulse intervals (i.e., from 3 to 20 msec.) is interpreted as arising from differences in the interaction between the members of a pulse pair for the two masking modes. This interaction would also appear to be due to central rather than peripheral mechanisms, since it occurs at interpulse intervals as long as 10-20 msec. Yet, because these intervals are sufficiently short, the interaction is likely to be "sensory" rather than attitudinal in nature.

Application of Monaural Temporal Interaction Paradigm to the Study of Temporal Processing in Psychiatric Patients

Among the more recent approaches using psychophysical techniques as a means of testing neurophysiological models with schizophrenic patients has
assumption that the peripheral and central processing levels as well as the
effector processes are unimpaired in schizophrenics, and that a basic deficit
lies in an inability to process relevant information at a sufficiently rapid rate
because of an abnormally slow primary rate of processing. Although one need not
follow Yates' argument with regard to the nature of the possible deficit in the
data processing system, one can retain his analysis concerning the four basic
levels at which breakdown can occur.

What mechanisms may be involved in data processing and how may those
mechanisms be effected in psychiatric patients? Neurophysiological models of
schizophrenic deficit based on measurements of evoked potential "recovery
functions" have recently been advanced which suggest that the deficit may be found
in certain inhibitory mechanisms. Several investigators (Floris, Morocutti,
Bernardi, Amabile, Risso, Sommer-Smith & Vasconetto, 1966; Spock, Dim & Mercer,
1966) have reported reduced recovery (i.e., longer time needed between stimuli)
of visual evoked potentials recorded from scalp electrodes in psychiatric patients
as compared to non-patients. Shagass and Overton (in press) found that at short
interpulse intervals psychiatric patients differed from non-patients with respect
to the evoked response to the second of a pair of stimuli using stimulation of
the ulnar nerve, i.e., recovery was prolonged in patients although their responses
to the first stimulus did not differ from that of the non-patients. Shagass
and Overton use a model of limbic system function proposed by Pribram (1967),
which deals with inhibition and is based on studies of recovery functions in
animals, in an attempt to explain the reduced recovery in psychiatric patients.
They postulate that the reduced recovery could be due to either overactivity of
the mechanisms enhancing inhibition or underactivity of the mechanisms reducing
afferent inhibition.
Although the model used by Shagass & Overtone is based on somatosensory evoked potential recovery functions, the general concept of possible impairment of sensory inhibitory mechanisms as applied to psychiatric populations can involve other sensory modalities as well. Thus, an intense auditory stimulus presented to a schizophrenic patient may result in a longer recovery period than in a normal subject. This would mean that forward masking in the patient would be extended in time because the effect of an intense stimulus on a succeeding stimulus is prolonged. The same could also be hypothesized for a backward masking paradigm. Thus, interference in neural function which leads to prolonged recovery after stimulation in a sensory modality implies that the interaction between two stimuli would extend for longer intervals. Psychiatric populations should show prolonged auditory masking functions relative to normal populations. This might mean that the functions generated for psychiatric populations utilizing a monaural temporal interaction paradigm may be displaced into a longer \( \Delta t \) region perhaps without affecting its shape. This would yield two partially overlapping functions, one for the normal population and one for the psychiatric population, in which the function for the psychiatric population is to the right, i.e., in a longer \( \Delta t \) region than the function for the normal population. In effect, we expected that the psychiatric population would perform as if the interpulse ratio (\( \Delta I \)) were larger for them, thus serving to displace their function into the longer \( \Delta t \) region.

Prior to beginning the experiments presented in this paper, we had gathered some pilot data comparing psychiatric patients and non-patients on our monaural temporal interaction measure. These data were generated using the forward versus backward masking discrimination paradigm presented in a three-alternative temporal forced-choice task. The independent variable, \( \Delta t \), was
constant in a block of trials but randomized across blocks. The sensation levels of the more and less intense members of the click pair were 50 dB and 30 dB, yielding an interpulse ratio of 20 dB. In Fig. 1, the average data for three patients is compared with the average data for two normals. The data are plotted as adjusted percent correct discrimination on the ordinate as a function of the temporal separation between members of a pair of clicks, \( \Delta t \), in logarithmic units on the abscissa. The curves for both patients and normals are nonmonotonic functions, rising initially, but then reversing and yielding a decrease in discrimination level with increase in \( \Delta t \). The curve for patients is, however, displaced to the right of the curve for normals, i.e. toward longer \( \Delta t \)s. Note especially that at \( \Delta t \)s of about 6 msec and longer the patients perform at a higher level of accuracy than normals. While this "better" performance on the part of the patients may arise from an extension of monaural temporal interactions out to longer \( \Delta t \)s in patients, it would be difficult to attribute the higher levels of accuracy in this \( \Delta t \) range to overall poorer attention or motivation in patients.

These preliminary data confirmed the feasibility of our approach and consequently we began our experiments. The first stage of our research (Experiment I) was designed to determine the stimulus parameters, i.e. the intensity of the more intense stimulus (I) and the interpulse ratio (\( \Delta I \)), and the values of the independent variable, \( \Delta t \), which yield large differences in the performance of patients and non-patients on our monaural temporal interaction measure. Several values of \( \Delta t \) were used to determine the form of the discrimination functions for patients and non-patients, and to verify the prediction that the function for patients would be displaced into a longer
Fig. 1. Average adjusted percent correct discrimination as a function of $\Delta t$ for three patients and two normals.
Δt region. The results of Experiment I served as the basis for selection of the stimulus parameters and Δt values used in the second stage of our research (Experiments II and III). In these experiments, only two values of Δt were used so as to permit the testing of larger samples of patients and non-patients on our monaural temporal interaction measure.

Experiment I: Patient vs. Non-Patient Parametric Study

Method

Subjects

Patients were selected from male new admissions to Brooklyn State Hospital who were between the ages of eighteen and thirty, and were known not to be mentally retarded, brain damaged or addicted to drugs or alcohol. The non-patients were male college students who were also between the ages of eighteen and thirty. Only non-patients were paid for their services.

Apparatus

The apparatus permitted independent control of the order of the members of the click pair, the intensity and temporal relationships of the monaurally presented clicks, as well as the length of the intertrial intervals and the intervals between test and comparison stimuli. The apparatus is described elsewhere (Babcock, Sutton & Barris, 1973). The acoustic characteristics of the click are described in Babcock, Sutton and Bruder (Enclosure #4). All stimuli were presented to the right ear.

Procedure

Forced-choice threshold. The S, wearing circumaural earphones, was seated in a sound attenuating booth. A fan inside the booth produced a low background noise. A block Up-and-Down Two-Interval Temporal Forced-Choice (BUDTIF)
technique, introduced by Campbell (1963), was used to measure the thresholds of each patient and non-patient.

**Forced-choice discrimination.** The S, wearing earphones and seated in the sound attenuated booth, was instructed to listen to three stimuli presented during each trial and to choose which one of the stimuli differed from the other two. Each S reported his choice by pressing one of three response buttons. If the choice was correct, a light informed the S of the correctness of his choice.

The psychophysical method was thus a three-alternative temporal forced-choice procedure. The two comparison stimuli were forward masking pairs of monaural clicks. The test stimulus consisted of a backward masking pair of monaural clicks. The onsets of the three click pairs were separated by 1 sec. The same click intensities were used for the forward and backward masking click pairs. The members of the click pairs were 45 and 60 dB SL. One patient and non-patient were also tested with click pairs whose members were 50 and 60 dB SL. The independent variable, the temporal interval (Δt) separating the members of the click pair, was manipulated over 3, 4, or 12 values ranging from 1 to 80 msec. The value of Δt was randomized across blocks of 12 trials. Brief rests were given outside the booth at the end of 4 blocks. Each S received extensive practice at each Δt value used in testing (in most cases, 72 trials per Δt). Each S was then tested on at least 96 trials of each Δt value.

**Interview.** Both patients and non-patients were interviewed after threshold measurement, using the Psychiatric Status Schedule (Spitzer, Fleiss, Burdock & Hardesty, 1964) and the Current and Past Psychopathology Scale (Spitzer & Endicott, 1969).
Results

One patient and one non-patient were tested in a parametric study, using 12 values of $\Delta t$. The results of this experiment are presented in Fig. 2 as the adjusted percent correct discrimination on the ordinate as a function of $\Delta t$ in msec. on a logarithmic abscissa. Fig. 2 (top) shows the data obtained when the more intense member of the pulse pair was 60 dB re threshold (SL) and the interpulse ratio ($\Delta I$) was 10 dB. The data in Fig. 2 (bottom) where obtained when more intense member of the pulse pair was 60 dB SL and $\Delta I$ was 15 dB. The curves for both the patient and the normal subject are nonmonotonic functions, i.e., the percent correct discrimination increases at the short $\Delta t$'s, decreases at the intermediate $\Delta t$'s (from about 4-12 msec. for the normal and 12-30 msec. for the patient) and increases again as $\Delta t$ increases to 80 msec. The major difference between the patient and the non-patient functions appears to be the displacement to the right of the patient curve relative to the non-patient curve, i.e., into a longer $\Delta t$ region. Consequently, a segment of the non-patient's curve at the shorter $\Delta t$'s is at higher discrimination levels than that of the patient. Similarly, at long $\Delta t$'s (from about 20 to 80 msec.), the discrimination levels for the non-patient are also higher than those of the patient. However, in the intermediate $\Delta t$ region (from about 4 to 16 msec.), the discrimination levels of the patient are higher than those of the non-patient.

These data agreed closely with our preliminary findings, and were encouraging because they indicated that it was possible to find psychiatric patients who perform at a higher level of discrimination than non-patients on some segment of the monaural temporal interaction function. Furthermore, it also confirmed that the parameters, i.e., 60 dB SL for the more intense member of the pulse pair and $\Delta I$ of 10 or 15 dB, are successful in yielded the
Fig. 2. Adjusted percent correct discrimination as a function of $\Delta t$ for a patient and a non-patient tested with an intensity of the more intense click of 60 dB SL and interpulse ratios ($\Delta I$) of 10 and 15 dB.
expected patient vs. non-patient differences in monaural temporal interactions.

To generate functions such as those in Fig. 2, however, takes a very long time. The period over which each patient was trained, tested, and interviewed extended over a month. It is impractical to rely on such a technique for gathering data on a large number of patients because, among other things, one is not able to guarantee that patients will be available for testing over such a long period of time. To validate such findings as these on larger samples required a modification of technique. Our approach was to select a few $\Delta t$ values which we anticipated, based on these findings, would yield large differences in the performance of patients and non-patients. We then proceeded to test if our choice of $\Delta t$ values yielded the predicted results.

Initial results obtained for three patients and four non-patients (at $I = 60$ dB SL and $\Delta I = 15$ dB) are shown in Fig. 3. Note first that the average data for patients is at an overall lower level of discrimination than the average data for non-patients. Also, increasing the $\Delta t$ from short to intermediate values (i.e., from about 2 to 14 msec.) had opposite effects on the discrimination level of patients and non-patients. The non-patients showed a decrease in discrimination level as the $\Delta t$ was increased from 2 to 12 msec., which would be expected based on our prior findings for non-patients (e.g., see Fig. 2). In contrast, the patients showed an increase in discrimination level as the $\Delta t$ was increased from 2 to 14 msec. This was followed by a decrease in discrimination level as the $\Delta t$ was increased from 14 to 60 msec. These data for patients would be expected given a shift of their discrimination function to the right, i.e., into a longer $\Delta t$ region than the function for non-patients (e.g., see Fig. 2).

A serious problem exists in interpreting the overall lower discrimination levels for patients than for non-patients (see the introduction). However, the
improvement in discrimination level as the $\Delta t$ was increased from short to intermediate values ($\approx 2$ to 14 msec.) in the data for patients compared to the decrement in discrimination level over this $\Delta t$ range in the data for non-patients would be more difficult to interpret in terms of overall poorer motivation or attention in patients. It is possible, therefore, that the slope of the function may be a more fruitful index than absolute discrimination level for comparing monaural temporal interactions in patients and non-patients.

Given a displacement of the discrimination function for patients into a longer $\Delta t$ region than the non-patient function, the prediction would be that patients would show a positive slope from short to intermediate $\Delta ts$, while non-patients would show a negative slope (e.g., see Fig. 2).

Additional data were gathered for two more patients and non-patients for the same parametric values (i.e., $I = 60$ dB SL, $\Delta I = 15$ dB) using four $\Delta t$ values ($\Delta t = 2, 12, 16$ and 35 msec.). These data are shown in Fig. 4. The averaged non-patient data again show overall higher discrimination levels than the average patient data. The slope of the non-patient function from 2 to 12 msec. is negative, i.e., there is a decrease in discrimination level as $\Delta t$ increases from 2 to 12 msec. In contrast, the average patient data from 2 to 12 msec. appears to have zero slope, i.e., discrimination level is constant from 2 to 12 msec. The functions for patients and non-patients were highly similar at $\Delta ts$ of 12 to 35 msec. These data seem to verify our initial impression that although patients may on the average perform at lower discrimination levels than non-patients the slope of the functions for patients and non-patients may nevertheless differ at short to intermediate $\Delta t$ values.
Fig. 4. Average adjusted percent correct discrimination as a function of $\Delta t$ for two patients and two non-patients.
Experiment 2: Patient vs. Non-Patient Study at Two $\Delta t$s: Backward Click Pairs as the Test Stimulus

Method

The method in this experiment was the same as in Experiment I, with the following exceptions. Two values of the independent variable, $\Delta t$, were used, i.e., 2 and 14 msec. The two $\Delta t$s were randomized by trial within blocks of 50 trials. Brief rests were given outside the booth after each block. Each S received a total of 100 trials at each $\Delta t$. A practice session, given on the first day of testing, consisted of the random presentation of blocks of 18 trials of each $\Delta t$, during which the S was told which was the different stimulus. The S then received 48 trials of practice at each $\Delta t$ where he had to choose the different stimulus.

Interview. Both patients and non-patients were interviewed after threshold measurement, using the Psychiatric Status Schedule (Spitzer et al., 1964) and the Current and Past Psychopathology Scale (Spitzer & Endicott, 1969) for some, while others were interviewed using a structured mental state interview schedule (Cooper, Kendell, Gurland, Sartorius & Farkas, 1969). The latter schedule was adapted from the Psychiatric Status Schedule and from the Present State Examination (Wing, Birley, Cooper, Graham & Isaacs, 1967).

Results

The average data for nine patients and eight non-patients are presented in Fig. 5. Note that at both $\Delta t$s the non-patients had a higher discrimination level than the patients. Both patient and non-patient functions appear relatively flat, i.e., there was little or no alteration in discrimination level as $\Delta t$ increased from 2 to 14 msec. Individual data for all of the patients and non-patients are shown in Fig. 6. These data show very large inter-subject variability
Fig. 5. Average adjusted percent correct discrimination at \( \Delta t \)s of 2 and 14 msec. for nine patients and eight non-patients.
Fig. 6. Adjusted percent correct discrimination at $\Delta t$ of 2 and 14 msec. for individual patients and non-patients.
between both patients and non-patients with respect to the discrimination level and the slope from 2 to 14 msec. Note also that most of the patients performed at, or close to, chance levels (i.e. zero adjusted percent correct discrimination).

Experiment 3: Patient vs. Non-Patient Study. Using 2 $\Delta t$ s: Both Forward and Backward Click Pairs Used as Test Stimuli

Method

The method was essentially the same as in Experiment 2. In this experiment, however, the test stimulus on any given trial could be either the forward paradigm or the backward paradigm. If the test stimulus was the forward paradigm, then the two comparison stimuli on that trial were the backward paradigm. If the test stimulus was the backward paradigm, then the comparison stimuli on that trial were the forward paradigm. Both $\Delta t$ and the paradigms which would serve as the test and comparison stimuli were randomized from trial to trial. This procedural change was introduced to encourage the S to attend to all three of the alternatives presented on each trial and to make his judgment based on a difference in one of the alternatives. We hoped, thereby, to minimize any possible dependence on memory of the test stimulus across trials. This dependence may arise in the following way. If, as in the previous experiments, the test stimulus is always in the backward mode, the subject can learn the cues involved in identifying the test stimulus. He may then listen to the first stimulus, then to the second stimulus, and decide whether the first or second stimulus was the test stimulus or if neither was the test stimulus, by a process of elimination, he could choose the third alternative. The S could, thereby, learn to ignore one or more of the stimuli in the three-alternative forced-choice task. This would introduce non-sensory factors (e.g. memory) into the test and could increase variability especially among naive Ss. We therefore modified
the procedure so that either the forward or backward modes could be the test stimulus on any given trial. There were a total of 300 trials at each $\Delta t$ (half with the test stimulus in the forward paradigm and half with the test stimulus in the backward paradigm). The practice session also consisted of trials on which either the forward or backward paradigm served as the test stimulus.

Thresholds were measured using an adaptation of the BUDTIF technique (Campbell, 1963), which permitted the use of a three-interval forced-choice task. A description of the details of this procedure as well as our rationale for using it are presented in Bruder, Sutton, Gurland and Yozawitz (Enclosure #1).

Patients and non-patients were interviewed after the threshold determination using a structured mental state interview schedule (Cooper et al. 1969).

Results

The left panel of Fig. 7 shows the average data for four patients and eight non-patients obtained when the test stimulus was in the backward masking mode, and the right panel of Fig. 7 shows their average data when the test stimulus was in the forward masking mode. Similar data were found for the forward and backward masking test stimuli. Data for the non-patients show higher discrimination levels at 2 and 14 msec. than for the patients. There is no clear indication of either a decreasing or increasing slope between 2 and 14 msec. in the data for patients or non-patients. Non-patients show a slight decreasing slope with the test stimulus in the backward mode and a slight increasing slope with the test stimulus in the forward mode. These differences, however, are very small. Patients performed close to chance (zero adjusted percent correct discrimination) at 2 and 14 msec., when the test stimulus was in the forward and backward modes.
Fig. 7. Average adjusted percent correct discrimination at $\Delta t$s of 2 and 14 msec. for four patients and eight non-patients.
Discussion

The monaural temporal interaction data for well trained patients and non-patients, who were tested using multiple values of the independent variable, $\Delta t$, conform to the prediction that psychiatric patients yield functions displaced into a longer $\Delta t$ region. When, however, we modified our procedures to permit testing of larger samples of patients and non-patients, e.g., by reducing the number of $\Delta t$ values to two, the results obtained were inconclusive. In the sections which follow, we discuss several problems encountered in our attempt to test large samples of naive Ss on what is apparently a complex discrimination task.

A major problem, which is evident in the data for Experiment II (see Fig. 5) and Experiment III (see Fig. 7), is the overall low level of discrimination shown especially by patients. One aspect of the procedure used in these experiments may have led to an increase in the difficulty of the discrimination task, and thereby, a lowering of the discrimination level. In these experiments, the values of $\Delta t$ were randomized from trial to trial rather than from block to block as in Experiment I.

The question of whether to fix or vary the value of the independent variable within a block of trials is difficult to answer because each alternative has its own advantages and disadvantages.

A S performing in a forced-choice discrimination task with instructions to choose the stimulus which is different from the other stimuli operates on the basis of a number of cues (see Kietzman & Sutton, 1963). Different values of the independent variable, e.g. $\Delta t$, may lead to different types of cues and, thereby, different bases for judging which stimulus is different from the other stimuli.
One advantage of keeping the value of the independent variable fixed within a block of trials in a forced-choice discrimination task is that the S may concentrate on cues associated with that one value of the independent variable. This would no doubt simplify the S's task and result in higher levels of discrimination than would be obtained if the value of the independent variable and the associated cues varied from trial to trial. Fixing the value of the independent variable within a block may be especially desirable when many values of the independent variable are used, for example, as in Experiment I.

The major methodological problem with this procedure stems from the differential sets or attitudes which the S may adopt across blocks that contain the different values of the independent variable. The S could label a block with a given value of the independent variable as "easy", while another block with a different value may be labeled as "difficult". The S might then attend or concentrate to a different extent during these blocks. If, for example, the S were to concentrate more during "difficult" blocks and less during "easy" blocks, this could reduce the difference in performance between the values of the independent variables in these blocks and thereby alter the slope of the discrimination function between these values. Thrane (1960), using a reaction time task, found evidence suggesting that Ss behave in such a manner when the values of a variable are presented in separate blocks.

Since this problem of differential set or attention across blocks could be especially troublesome when comparing the discrimination performance of naive patients and non-patients at only two values of the independent variable, we decided in Experiments II and III to randomize these two values from trial to trial within blocks. The advantage of this procedure is that the S does not know before each trial what stimulus value will be presented, and it
is, therefore, more likely that he will attend equally during trials containing the different values of the independent variable. The main disadvantage of varying the value of the independent variable, $\Delta t$, from trial to trial is that the cues which serve as the bases for discrimination in our three alternative forced choice task will then also vary from trial to trial. This could increase the difficulty of the task, especially for naïve patients and non-patients, and thereby decrease the overall level of discrimination. We had hoped that the use of only two $\Delta t$ values would minimize this problem but the results of Experiments II and III would indicate that both patients and non-patients found the task to be quite difficult.

Another problem encountered in our comparison of the monaural temporal interaction data for groups of naïve patients and non-patients is high inter-subject variability. As was shown in the results for Experiment II (see Fig. 6), this inter-subject variability was evident in the data of non-patients as well as patients. There was high variability both with respect to the overall level of discrimination and the slope of the discrimination function between the two $\Delta t$ values. Note, for example, that the functions for some non-patients had positive slopes, while those for other non-patients had negative slopes. When such individual data with opposite slopes are averaged, the resulting average function will have a slope equal to, or close to, zero (see Fig. 5). The averaged functions will tend not to show large changes in discrimination level as a function of $\Delta t$, even though the individual functions might show such trends. Thus, inter-subject variability in the slopes of the individual functions may account for the failure to find a change in discrimination level as a function of $\Delta t$ in the average data for patients and non-patients in Experiments II (see Fig. 5) and Experiment III (see Fig. 7). One possible
source of this inter-subject variability in slope may stem from differences in the displacement of the functions of these Ss along the Δt axis, i.e., differences in the Δts at which their functions increase or decrease. For example, Ss who show a positive slope between the Δts of 2 and 14 msec. may have discrimination functions that are displaced to the right toward longer Δts (e.g., see the functions for the patient in Fig. 2), while other Ss who show a negative slope may have discrimination functions in a shorter Δt range (e.g., see the functions for the normal subject in Fig. 2). It could be argued that sub-groups of patients and non-patients who are more homogeneous in terms of their psychiatric symptomatology would yield less inter-subject variability. There was, however, no evidence in our available data that the discrimination performance of patients or non-patients was related to symptomatology.

The numerous difficulties that we encountered in using what is evidently a complex and demanding discrimination task led us to consider alternative measures that might prove to be more useful for studying monaural temporal interactions in patient and non-patient populations. One measure that could prove to be especially valuable in this context is simple reaction time. The major advantage of this measure is that it involves a very simple response which can be performed successfully by most patients. Moreover, a number of recent studies have applied simple reaction time to measure the temporal processing of sensory information (e.g., Bruder & Kietzman, 1973; Collins, 1972; Grossberg, 1968, 1970; Kietzman & Gillam, 1972; Raab, 1962). We have, therefore, turned our attention toward the development of a simple reaction time measure of monaural temporal interactions to use in our research with psychiatric patients and non-patients.
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Footnote

1 This adjustment took into consideration the fact that the subject could make the correct choice with a priori probability of 0.33 on the basis of chance alone. A further adjustment was made to extend the range of discrimination values from 0% to 100%. This adjusted percent correct was computed as (Percent correct -0.33)/(1 - 0.33).