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Cognitive Functioning in Schizophrenia

1. Stimulus Analysing and Response Selection Processes

By W. L. MARSHALL

It has long been accepted that inadequate or abnormal cognitive performance is a characteristic of those patients described as schizophrenic (Cameron, 1938, 1939; Goldstein, 1939). A number of theories have been advanced to suggest that the basic deficit underlying this abnormal performance lies in impaired information processing. McGhie (1969, 1970) and Payne (1960) consider the defect to be in the filter that normally operates to exclude irrelevant stimuli, while Yates (1966a, 1966b) suggests that the impairment may reflect a slowed rate of information transfer in the primary processing channel. Hawks and Marshall (1971) also argue for slowed processing, but although they talk about overload due to inappropriately filtered input they appear to identify their position with Broen's (1968) response interference theory.

McGhie's position derives from a careful consideration of clinical evidence followed by direct experimental examination of the clinically derived hypotheses. The experiments that McGhie and his colleagues employed (Chapman and McGhie, 1962; Lawson, McGhie and Chapman, 1967; McGhie, Chapman and Lawson, 1964, 1965a, 1965b), permit direct inferences to be made about the effects of distraction on performance, and replicate some of the accepted paradigms for investigating information processing variables. Similarly, the research suggestions of Yates (1966a) represent attempts at direct testing of hypotheses about information processing defects. The same cannot be said, however, of Payne's early work (Payne, 1960, 1962, 1966; Payne, Caird and Laverty, 1964; Payne and Hewlett, 1960; Payne, Mattussek and George, 1959), nor can the study of Hawks and Marshall (1971) provide the basis for inferences about defective filtering of input. Indeed, Payne's studies of 'overinclusion' in schizophrenic patients have been criticized, both for the technical limitations of the tests used (Foulds *et al.*, 1967; Hawks, 1964; Watson, 1967) and on the ambiguity of the interpretations of his findings (Gathercole, 1965).

In view of recent findings (e.g. Hawks, 1967; Payne and Caird, 1967; Payne, Hochberg and Hawks, 1970; Payne and Van Allen, 1969), Payne has changed his position, and now concludes that 'plausible though the "defective filter" explanation of overinclusive thinking sounds, experiments have not supported it' (Payne, 1971, p. 83). A more reasonable conclusion might have questioned the usefulness of the concept of overinclusive thinking.

Even those theories (McGhie, 1970; Yates, 1966b) that require a less circuitous inferential path from the data are open to criticism on other grounds. All the theories discussed so far are based on Broadbent's (1958) model of normal information processing. There are at least two reasons why Broadbent's model may not be an acceptable reference system for discussing schizophrenics' problems. In the first place studies of normal attentional processes (Gray and Wedderburn, 1960; Moray, 1959; Triesman, 1964) have undermined the acceptance of Broadbent's statements and have led to either the rejection of a perceptual filter theory (Deutsch and Deutsch, 1963) or to serious modifications of such models (Broadbent and Gregory, 1964; Triesman, 1964). Even the alternative, much modified, input filtering models have been seriously challenged (Greenwald, 1970a; 1970b; Norman, 1969).

The second reason for doubting the relevance of Broadbent's model has to do with data obtained from schizophrenics contradicting the assertion that the breakdown in their filtering is

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due to a relative inability to discern the physical properties of the message. This assertion is essential in order to consider schizophrenics' performance in Broadbent's terms, since in his theory filtering is based on physical properties. Loren Chapman, in a series of studies (Chapman, 1956a, 1956b, 1958, 1961; Chapman and Taylor, 1957), has demonstrated that schizophrenics are not distracted by just any irrelevant stimuli in a conceptual task, but only by those stimuli bearing some relationship to the correct items. Indeed, the closer the associational relationship between the correct and extraneous item the greater the distractive power of the irrelevant stimuli (Downing, Ebert and Shubrooks, 1963; Downing, Shubrooks and Ebert, 1966; Gottesman, 1964). Chapman's studies have been replicated and extended, with essentially the same results (Blumberg and Giller, 1965; Burstein, 1961; Feinberg and Mercer, 1960; Gonen, 1970; Grimes and McGhie, 1972; Hawks and Marshall, 1971). The important point to note for Broadbent's model is the absence of a dimension of physical discriminability matching the distractive powers of the items in Chapman's studies. An experiment by Lawson (1962) also has relevance for this issue. Using a 'low-pass filtering' technique to distort a normal voice, Lawson was able to obtain a series of 'irrelevant' messages that ranged from clearly discriminable from the normal voice to near the region of the psychophysical threshold. All subjects were adversely affected by decreasing discriminability of the messages, and schizophrenics were no more handicapped in this respect than normals. Thus if schizophrenics do have filtering difficulties, these difficulties are not due to a relative inability to discriminate the physical properties of stimuli.

If the defective filter theorists are to maintain their argument they must turn to more appropriate models of attention. Triesman's model has some advantages over Broadbent's, but also some disadvantages (Norman, 1969). Deutsch and Deutsch's (1963) response selection theory may provide a more satisfactory model for considering schizophrenics' performance difficulties. Such a model would seem to fit the data discussed by Broen (1966, 1968), and is especially suited to Broen's interpretation of the evidence. There is no problem for schizophrenics, as Broen sees it, in sampling input. The problem is simply that the probabilities of competing responses have been more nearly equalized in schizophrenics, and this causes them to have difficulties in selecting the appropriate response.

The resort to models of attention and response selection rests on the frequent observation that schizophrenics cannot handle information under certain conditions with the same facility as normal subjects, and that they generally perform at a less efficient level than most other psychiatric patients. In choosing *either* an attentional *or* a response selection model as a basis for understanding schizophrenics' problems we necessarily restrict our view. Schizophrenics may experience difficulties in either or both stimulus analysing or response selection. They may also have difficulties in holding material in the short-term memory mechanism, in retrieving memorial information, in transferring information within the system, or, in line with Bleuler's (1911) suggestion, in associating material at some central level in the system. A model that permits the description of capacities at most, if not all, these levels is provided by the recent work on choice reaction time (CRT) with normal subjects. The data from CRT studies have been analysed according to current information theory models that have as their basis a modification of Donders' (1868) argument of additivity. Whereas Donders argued that increasing complexity adds, in a logarithmic fashion, a cognitive component to the motor speed component of simple reaction time, modern theorists posit a log/linear relationship between increases in complexity and reaction-time (Hick, 1952; Smith, 1968; Sternberg, 1969). This relationship appears to hold irrespective of whether the increases in complexity refer to stimuli, responses, or memory load (Briggs and Blaha, 1969; Briggs and Swanson, 1969, 1970; Swanson and Briggs, 1969). It is possible, using these kinds of analyses of CRT data, to isolate the locus of difficulty in information processing. Such analyses could be applied with profit to schizophrenics' performance and may facilitate the evaluation of various theories.

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Experimental Study

Aim: The aim of the study is to compare the CRT performance of schizophrenics with other subjects when complexity (or uncertainty) is increased across stimulus values and response values independently. In this way an evaluation can be made of McGhie and Payne's defective filter theories and of Broen's argument that schizophrenics have response selection difficulties. Slade (1971) examined schizophrenics' performance on a CRT task, but unfortunately confused stimulus and response uncertainty, so that all he was able to conclude was that schizophrenics were seriously affected by increasing complexity.

For the stimulus filter argument to be correct, schizophrenics should not only have slower reaction times (RT) than other subjects at all levels of stimulus uncertainty, but should also be more affected by increases in stimulus complexity. That is, the slope of the function relating decision times to stimulus uncertainty should be both higher and steeper for schizophrenics than for other subjects. If Broen (1968) is correct in asserting that the schizophrenic's problem is in selecting the appropriate response, then their response patterns should exhibit a higher and steeper slope of the function relating decision time to response uncertainty than those of other subjects.

Alternative proposals (Court and Garwoli, 1968; Yates, 1966a, 1966b), which specifically deny difficulties in input analysing, would not predict a steeper slope to the stimulus function for schizophrenics. Although these theories would predict slower times with increases in the amount of relevant stimuli, since this requires more decisions per unit time, there is no reason to suppose that additional irrelevant stimuli should cause further slowing. Indeed Yates (1966a) specifically claims that it is not the intrusion of irrelevancies that causes apparent thought disorder in schizophrenics, but rather the loss of relevant information.

Method

Subjects: There were three groups of subjects comprising 21 schizophrenics, 21 neurotics and 21 penitentiary inmates. The last group served as normal controls and permitted matching for institutionalization. The schizophrenics were chosen from patients whose diagnosis was unequivocal and who had not been treated with psychosurgery, nor in the previous month experienced electroconvulsive therapy. Medication ranged from zero to 200 mg. b.i.d. Serentil plus 200 mg. b.i.d. Mellaril. The penitentiary inmates were orthogonally matched, as far as was possible, with the schizophrenics on IQ, education, age and duration of current stay in an institution. Inmates who showed any evidence of psychiatric involvement were excluded. There was no thorough attempt to match neurotic subjects, but statistical analyses did not reveal any significant differences in IQ, education, or age. However, the neurotics had spent significantly less time in an institution, both presently and throughout their life, than either the schizophrenics or the inmates.

Procedure

A card-sorting task based on a test used by Crossman (1953) served as the measure of CRT. This test was chosen because it is a continuous task and therefore has certain advantages over the more popular discrete RT task. Data on the orienting response (Easterbrook and Costello, 1970) suggest that responses to stimuli having a sudden onset will be markedly different for schizophrenics than for other subjects. A continuous CRT method overcomes these difficulties. A further advantage of a continuous task over the usual discrete CRT procedure involves the elimination of time-uncertainty. Time-uncertainty has been shown (Creamer, 1963; Gottsdanker and Way, 1966; Klemmer, 1956, 1957; Näätänen, 1970; Nickerson, 1967), to contribute to reaction-time, and cannot simply be eliminated by the presence of a warning signal and regular fore-periods (Drazin, 1961; Karlin, 1959; Zahn, Rosenthal and Shakow, 1963).

In order that CRTs should provide a basis for estimating decision times, performance must be the result of an optimal balance between speed and accuracy. Subjects are therefore urged to go as fast as possible without making errors. The usual criterion for accurate performance is to reject any performance that produces more than 2 per cent errors (Smith, 1968). It turned out not to be necessary to apply this rule, as all subjects returned zero error scores.

There were three different decks of cards used, each deck containing 32 cards. In Deck 1, 16 cards displayed a blue circle, and 16 a yellow circle. Deck 2 had 16 circles (8 blue and 8 yellow) and 16 squares (8 blue and 8 yellow). Deck 3 had 8 circles, 8 squares, 8 diamonds and 8 triangles, each shape appearing four times in blue and four times in yellow. Thus each deck had a different degree of stimulus uncertainty

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associated with it, where uncertainty is defined in information theory terms (Shannon, 1948).

The subjects were asked to sort Deck 1 into two piles according to colour. Deck 2 was to be sorted twice, once according to colour, and once according to both shape and colour. Deck 3 was to be sorted three times, once by colour, once by shape, and once by both shape and colour.

Thus Deck 1, which contains one bit of stimulus uncertainty, is sorted according to instructions that result in one bit of response uncertainty for the subject. Deck 2, which contains two bits of stimulus uncertainty is sorted in two ways: one giving one bit of response uncertainty (colour alone); and the other two bits of response uncertainty (colour and shape). Deck 3 contains three bits of stimulus uncertainty, and is sorted in three ways: one resulting in one bit of response uncertainty (colour alone); one resulting in two bits of response uncertainty (shape alone); and one resulting in three bits of response uncertainty (colour and shape).

Each deck was shuffleld before presentation to ensure random ordering, and the order of occurrence of the decks and the sorts within decks was also randomized. Subjects were handed the cards face down, and were instructed to turn each card over individually and then place the card on the top of a guide card according to the appropriate instructions. Subjects were advised to sort as fast as possible without making errors. All subjects were given three practice trials with each possible sort before data collection commenced.

Results

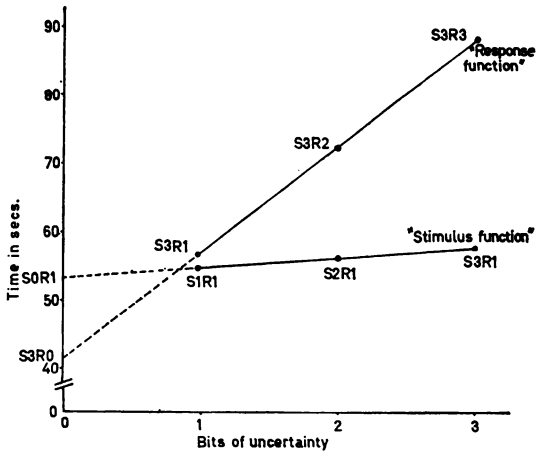
The RTs for each subject were recorded over three trials for each condition, and means of these three recordings were taken as representative of the subject's score at each level of uncertainty. Such scores, however, include, in addition to the decision times, the time required by the subject to make the necessary sorting movements. The evaluation of the effects of varying stimulus and response uncertainty on decision processing requires a model that will allow separate estimates of movement and decision times to be derived from the data.

CRT model

Estimates of movement time have been secured (Slade, 1971) by having subjects sort blank cards according to the instructions used in the testing procedure. Observation of subjects sorting blank cards made it clear that the movements involved were quite different from those produced in the actual task, and for this reason such estimates were not used.

Since there is abundant evidence that CRT is a linear function of the level of uncertainty as measured in bits of information (Briggs and Swanson, 1970; Hick, 1952; Smith, 1968; Sternberg, 1969), the intercept of such a function should provide the basis for estimating movement time. In the present study we have two functions relating RT to uncertainty across three bits of uncertainty. For each subject a line-of-best-fit was derived for each of these functions from the three recordings taken at each level of uncertainty. Graph 1 describes these functions for a representative subject.

The 'response function' describes the line-of-best-fit for increases in response uncertainty at three bits of stimulus uncertainty (this being the only level of stimulus uncertainty that provided three levels of response uncertainty). The intercept of this function, then, provides an estimate of the time required to sort three bits of stimulus uncertainty at zero bits of response uncertainty. We will call this value S_3/R_0. The 'stimulus function' describes the line-of-best-fit for increases in stimulus uncertainty at one bit of response uncertainty (this being the only level of response uncertainty that provided three levels of stimulus uncertainty). The intercept of this function, then, provides an estimate of the



Graph 1.—Lines-of-best-fit for the sorting times of a representative subject.

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time required to sort one bit of response uncertainty at zero bits of stimulus uncertainty. We will call this value So/R1.

Movement time can be understood as the time taken to sort in the absence of any decisions, i.e. the time taken to sort zero bits of stimulus uncertainty at zero bits of response uncertainty. Thus movement time will be represented by SO/RO, and so the intercepts of both functions contain components of decision times. The slopes of each function will, however, enable us to adjust our values to estimate SO/RO. The slope of each function represents the changes in RT that result from unitary changes in uncertainty. Therefore, the slope of the response function is an estimate of the time taken to sort one bit of response uncertainty (R1). Similarly, the slope of the stimulus function provides an estimate of S1. If we subtract R1 from the intercept of the stimulus function So/R1 the result is So/Ro, i.e. an estimate of movement time. Likewise, if we substract 3(S1) from the intercept of the response function S3/Ro the result again is So/Ro, or, alternatively, an estimate of movement time. Statistical analyses of all the schizophrenics' data revealed no significant differences between the two estimates, and in fact the correlation that results from comparing them was substantial ($r = 0{\cdot}996$). The function relating the two estimates of movement time had a slope that did not significantly differ from unity, and the intercept did not differ from zero. The first alternative was chosen as the estimate of movement time, and was subtracted from the values at each level of response and stimulus uncertainty to give estimates of decision times for each subject.

Tests of the model: Estimates of scores of two bits of response uncertainty at two bits of stimulus uncertainty can be derived from the estimates of movement and decision times. If the model is incorrect, these derived scores should differ significantly from those actually obtained. A correlated 't' test did not produce a significant ratio, suggesting that the estimated scores did not differ from the obtained data.

For the estimates of movement time to be equivalent, and in particular for the estimate of S3 to be adequate, there should not be a 'stimulus uncertainty' × 'response uncertainty' interaction. Therefore, if we compare functions representing different levels of uncertainty on one factor across different levels of the other factor, these functions should be parallel. Effectively this would provide a rationale for the simple additivity of stimulus and response uncertainty in determining reaction-time. Taking two levels of response uncertainty (one and two bits) at two levels of stimulus uncertainty (two and three bits) for the schizophrenics' data, an analysis of variance did not reveal any significant interaction effect ($F[1,40] = 0{\cdot}145$). Additivity thus holds within the range of uncertainty used in this study.

Derived RT data

All derived scores were divided by 30 to produce estimates of sorting times per card. Table I shows the RT data converted to movement times and decision times.

Extracting the data for changes in decision times with (a) changes in stimulus uncertainty, and (b) changes in response uncertainty, we can examine the separate effects of stimulus and response complexity on the various groups. These two functions are expressed in Graphs 2 and 3.

An analysis of variance of the data in Graph 2 revealed a significant 'groups' effect ($F[2,60] = 24{\cdot}42$; $p < 0{\cdot}01$), a significant effect due to changes in the level of response uncertainty ($F[2,120] = 619{\cdot}45$; $p < 0{\cdot}01$), and a significant interaction effect ($F[4,120] = 31{\cdot}52$; $p < 0{\cdot}01$). A similar analysis of the data in Graph 3 produced a significant 'groups' effect ($F[2,60] = 17{\cdot}75$; $p < 0{\cdot}001$), a significant effect due to changes in stimulus uncertainty ($F[2,120] = 13{\cdot}79$; $p < 0{\cdot}01$), and a significant interaction effect ($F[4,120] = 4{\cdot}40$; $p < 0{\cdot}01$).

A test of homogeneity of variance using the 'Fmax' statistic on both sets of data indicated a significant deviation from homogeneity in the case of the response function ($Fmax = 59{\cdot}68$; $p < 0{\cdot}01$), and in the case of the stimulus function ($Fmax = 37{\cdot}37$; $p < 0{\cdot}01$). Non-parametic analyses, however, gave essentially the same results as the parametric tests, except that there is no distribution-free method for deriving interaction effects that has a demonstrated efficacy (Bradley, 1968). In view of the

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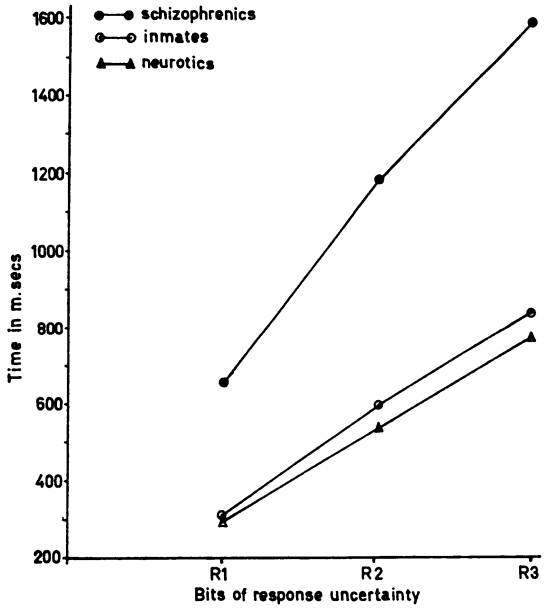
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TABLE I

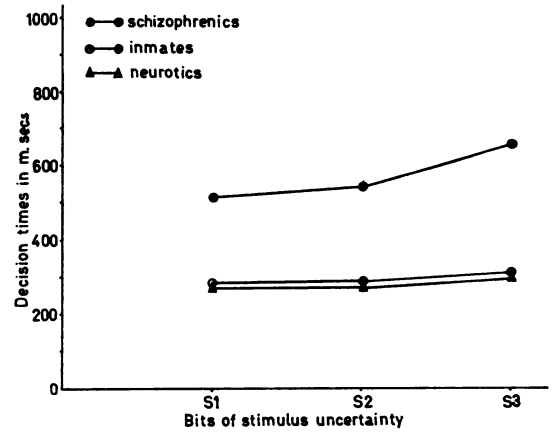
Reaction-time data for all groups

Groups	Movement times	Reaction-times (in m.secs)					
		Decision times*					
		S1R1	S2R1	S2R2	S3R1	S3R2	S3R3
Schizophrenics ..	$\bar{X}$ =1242·67 Md=1231·00 s.d.= 443·00	$\bar{X}$ = 513·19 Md= 462·00 s.d.= 238·52	$\bar{X}$ = 544·48 Md= 493·00 s.d.= 293·51	$\bar{X}$ =1049·67 Md=1007·00 s.d.= 470·45	$\bar{X}$ = 651·71 Md= 504·00 s.d.= 401·87	$\bar{X}$ =1182·00 Md=1047·00 s.d.= 499·63	$\bar{X}$ =1580·29 Md=1404·00 s.d.= 620·66
Neurotics ..	$\bar{X}$ = 928·71 Md= 974·00 s.d.= 169·47	$\bar{X}$ = 265·95 Md= 228·00 s.d.= 96·76	$\bar{X}$ = 271·38 Md= 250·00 s.d.= 110·44	$\bar{X}$ = 495·52 Md= 468·00 s.d.= 143·15	$\bar{X}$ = 292·86 Md= 260·00 s.d.= 120·57	$\bar{X}$ = 533·86 Md= 530·00 s.d.= 155·27	$\bar{X}$ = 767·95 Md= 718·00 s.d.= 220·28
Inmates	$\bar{X}$ = 765·76 Md= 743·00 s.d.= 258·38	$\bar{X}$ = 279·86 Md= 288·00 s.d.= 66·13	$\bar{X}$ = 288·66 Md= 307·00 s.d.= 76·34	$\bar{X}$ = 568·95 Md= 601·00 s.d.= 119·27	$\bar{X}$ = 310·05 Md= 309·00 s.d.= 78·57	$\bar{X}$ = 591·00 Md= 622·00 s.d.= 125·53	$\bar{X}$ = 834·95 Md= 843·00 s.d.= 195·23

* Decision times were described according to the levels of uncertainty involved. For example, S1 indicates 1 bit of stimulus uncertainty and R1 indicates 1 bit of response uncertainty therefore S1R1 indicates 1 bit of stimulus uncertainty at the level of 1 bit of response uncertainty, that is, the single sort available for Deck 1. The remaining columns are described in the same terms.



GRAPH 2.—Mean decision times at 3 bits of stimulus uncertainty across three levels of response uncertainty.



GRAPH 3.—Mean decision times at 1 bit of response uncertainty across three levels of stimulus uncertainty.

lack of homogeneity of variances, and the congruence of the parametric and non-parametric overall analyses, it seemed more appropriate to examine the differences within effects by distribution-free statistics.

Mann-Whitney U tests of the data in Graph 2 showed that the schizophrenics had a higher function relating decision time to increases in response uncertainty than either the neurotics ($z = 4{\cdot}77$, $p < 0{\cdot}01$) or the inmates ($z = 4{\cdot}65$, $p < 0{\cdot}01$). Inmates and neurotics did not differ ($z = 1{\cdot}23$). Similar analyses of the data in Graph 3 gave essentially the same results. Schizophrenics were slower than the inmates ($z = 4{\cdot}31$, $p < 0{\cdot}01$), and slower than the neurotics ($z = 4{\cdot}31$, $p < 0{\cdot}01$), whereas the neurotics and the inmates did not differ ($z = 1{\cdot}17$).

In order to determine whether stimulus analysing is more difficult for schizophrenics than deciding between responses, we must compare changes in CRTs with increases in uncertainty across one factor while holding the other factor constant. To do this we can take the obtained data at one bit of response uncertainty with increases in stimulus uncertainty and compare this with derived data for one bit of stimulus uncertainty with increases in response uncertainty. An analysis of variance of such data revealed a significant interaction effect between type of uncertainty (stimulus vs. response) and level of uncertainty ($F[2,80] = 92{\cdot}37$; $p < 0{\cdot}01$). This interaction effect indicated that the response function was steeper than the stimulus function, suggesting that response decisions are more difficult for schizophrenics than stimulus analysing.

An analysis of variance of the movement times revealed a significant 'group' effect ($F[2,60] = 13{\cdot}16$; $p < 0{\cdot}005$), which the Mann-Whitney U tests showed to be the result of differences between all groups. The schizophrenics were significantly slower in their movements than either the neurotics ($z = 2{\cdot}67$, $p < 0{\cdot}005$) or the inmates ($z = 3{\cdot}84$, $p < 0{\cdot}005$), and the neurotics were significantly slower than the inmates ($z = 2{\cdot}55$, $p < 0{\cdot}005$).

The suggestion that the results might have been due to the effects of medication was not confirmed. The schizophrenics' medication was independently ranked by two psychiatrists* for sedative effects and the rank-order correlation of the two ratings was highly significant ($rho = +0{\cdot}87$, $p < 0{\cdot}001$). The mean of these rankings for each subject was then correlated with the estimates of movement time, response decision time and stimulus decision time for all subjects. None of the resulting correlations approached

* Thanks to Drs. C. McPherson and J. Peachey for their help in ranking the data.

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significance. The highest coefficient was that resulting from comparing movement with medication level (rho = +0·185).

Discussion

The results indicate that the schizophrenics were slower in executing the movements necessary to sort cards and in their ability to select responses than either the inmates or the neurotics. The schizophrenics were also slower at making decisions about stimuli than either the inmates or the neurotics. Both the response selection problems and the stimulus analysing difficulties of the schizophrenics became relatively more pronounced with increases in uncertainty, compared with these effects on the inmates and the neurotics. Stimulus uncertainty was not as great a source of difficulty for schizophrenics as was response uncertainty. These findings are consistent with earlier RT studies by Venables (1958, 1965). He found that when response complexity was low in a verbal RT task there was no interaction between stimulus complexity and differences in schizophrenics' and normals' performance, i.e. the slopes of the stimulus complexity/reaction time functions for both groups of subjects were the same (Venables, 1958). In his later study (Venables, 1965), stimulus complexity was held constant. Schizophrenics did not differ from normals in performance at minimal levels of response complexity, but the slopes of the functions differed significantly, indicating a relatively increasing difficulty for schizophrenics as the response complexity increased. Kausler, Lair and Matsumoto (1964) have obtained similar results.

The observation that schizophrenics have a higher and steeper slope to the function relating decision time to response uncertainty than other subjects, supports Broen's (1968) claim that difficulties in selecting the appropriate response is the problem for schizophrenics. This finding is not inconsistent with Yates' (1966a) theory. The effects of stimulus uncertainty support the argument that schizophrenics have problems in dealing with the stimulus properties of input, and this is in accordance with the filter defect theories of McGhie (1970) and Payne (1960). Of course these results do not confirm the suggestion that schizophrenics have filtering problems. It may be that the results are due to other difficulties. For instance, stimulus analysing has been shown to involve an encoding process as well as a sampling or filtering of input (Swanson and Briggs, 1969).

The presence of difficulties at both the stimulus and response ends of the processing system is inconsistent with all theories (whether defective filtering, slowed transfer in the primary processing channel, or response selection problems) that claim a single specific defect as basic to the schizophrenic's problems. It is clear that schizophrenics' information processing capacities are defective compared with those of other subjects, and that this relative deficit is not isolated to any one aspect of processing. The specification of the extent of these difficulties will have to await further study, and the CRT task seems well suited to the description of such defects.

The flatter slope of the function relating decision times to stimulus uncertainty, compared to that relating decision times to response complexity, suggests that response selection problems are of more importance than defective filtering in understanding schizophrenics' performance. A possible reason for this may relate to the novelty of the stimuli. It may be that for schizophrenics the effects of stimulus complexity are maximal with novel stimuli. Even the limited practice given in the present task may have been sufficient to reduce stimulus uncertainty effects. Broadhurst (1958a, 1958b) obtained a significant practice effect for both schizophrenics and normals, but these effects were greater for the schizophrenic subjects. In describing the work dealing with the orienting responses of schizophrenics, Easterbrook and Costello (1970) note the importance of novelty. They suggest that the experimental procedures used by McGhie and his colleagues produced an important orienting response, and that this disruptive response may account for the apparent distraction effects. With sufficient practice orienting responses could be expected to disappear. An incidental observation in the present study suggests that practice effects may be slower in schizophrenics but nevertheless may occur rapidly. In the pre-test practice schizophrenics

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needed far more additional instructions than other subjects, but they did not appear to lose this instructional set once actual trials began. This observation is relevant to Shakow's (1962, 1963) 'mental set' theory. It is possible that schizophrenics are able to overcome the tendency to adopt minor sets if instructions are repeated frequently and if they become familiarized with the stimuli.

In summary, then, the evidence indicates that schizophrenics have difficulties in choosing the appropriate response once stimuli have been analysed, and this difficulty is exacerbated by increasing complexity. Schizophrenics also have a somewhat less marked problem in analysing input, and this difficulty may be overcome to some extent by practice. In addition, schizophrenics are slower than other subjects in executing movements, indicating that they are generally slowed across all the functions examined in this study.

Perhaps the most important observation of the present study relates to the adequacy of the model for representing the CRT data of schizophrenics. The capacity of CRT studies to provide detailed analyses of various aspects of information processing make such studies particularly suited to the examination of schizophrenics' functioning. The results of further studies of schizophrenics' CRTs, should be of considerable value for an understanding of the nature of the cognitive dysfunction of these patients.

Summary

It is suggested that those theories of schizophrenics' cognitive functioning that posit information processing difficulties as the basis for the defective functioning are inadequate. One basic inadequacy is that all these theories rest on an outmoded model of information processing. Models of choice reaction time (CRT) seem more suited to an understanding of schizophrenics' difficulties and allow a detailed analysis of functioning that would permit the description of schizophrenics' cognitive defects.

A CRT analysis of card sorting performance indicated that schizophrenics were slower than neurotics and matched penitentiary inmates across all measures. Schizophrenics were slower than other subjects in their movements, and had more difficulty in analysing stimuli and selecting the appropriate response. Increases in both stimulus complexity and response uncertainty affected schizophrenics more than other subjects, with response uncertainty effects being greatest. The effects of stimulus uncertainty appeared to be related to novelty.

The results are discussed in relation to several theories and a case is made for further CRT studies of schizophrenics' functioning.

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11. Conceptual Performance under Unpaced, Speeded, and Slowed Conditions

Abnormal performance on concept tasks is accepted as a characteristic behaviour of schizophrenic patients (Buss, 1966). The deviant responses of schizophrenics on these tests have been considered to be the result of various basic problems, for example, overinclusive thinking

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(Cameron, 1939; Payne, 1960); concreteness (Goldstein, 1946); distractibility (McGhie, 1969); and inability to maintain a major set (Shakow, 1962, 1963). Hawks and Marshall (1971) have suggested that the schizophrenic's unusual conceptual performance is the result of an adjustment to an underlying defect in information processing. They claim that schizophrenia slows the rate at which information is processed. Yates (1966a, 1966b) also considers schizophrenics to be slowed in the rate at which they can process information, however, he puts the locus of this difficulty in the primary processing channel, while Hawks and Marshall appear to suggest a more general slowing. According to Hawks and Marshall, some schizophrenics adjust to this by slowing the rate at which they deal with problems, thereby appearing slow but retaining their accuracy. Other schizophrenics are said to attempt to maintain their pre-morbid operating rate, and consequently make errors but do not appear retarded.

The implications of this theory for performance on concept tests completed under various conditions were described by Hawks and Marshall (1971), and a limited test of these implications was made. A more complete test is, however, necessary to examine the theory more carefully.

Experimental Study

Aim: The aim is to test certain implications of Hawks and Marshall's theory. Specifically, they claimed that some schizophrenics would make errors on Chapman's (1958) test, while others would not. The former they called 'over-inclusive', and it was supposed that forcing these subjects to slow the rate at which they completed the test would reduce their errors. The other schizophrenics were called 'non-over-inclusive' and it was claimed that speeding them would increase their errors. The results of a study examining these implications (Hawks and Marshall, 1971) supported the theory.

A more thorough test would involve having schizophrenics complete Chapman's task under unpaced, speeded and slowed conditions, and comparing their performance with that of normal subjects under unpaced and speeded conditions. Since normals do not make errors when unpaced it is obviously impossible for them to benefit by slowing, so this condition for the normals is unnecessary.

Hawks and Marshall's theory would predict (in common with many other theories) that schizophrenics, as a group, would make more errors than other subjects on Chapman's test under unpaced conditions. Speeding may not significantly increase the schizophrenics' errors (since they already produce considerable errors), whereas it should make the normal subjects show schizophrenic-like performance. Slowing should decrease the errors of the schizophrenic subjects.

Method

Subjects: The groups are described in an earlier study (Marshall, 1973). They comprised 21 schizophrenics, 21 neurotics and 21 inmates from local penitentiaries. All groups were matched for IQ (Mill Hill), education, and age. The schizophrenics and the inmates were also matched on the length of their current stay in an institution.

Procedure: Chapman's test has been described elsewhere (Chapman, 1958), but briefly it consists of two matching sets of cards. Guide cards have three words printed on them, one of which describes a concept that is a member of the same class as the word appearing on the matching response card. Another of the guide card words describes a concept that belongs to a class associated with, but not the same as, the word on the response card. The third guide card word is unrelated to the response card word.

The subject is required to place the response card in the box under the word of the same class on the guide card. An error occurs when a subject places a response card under either the associated or the irrelevant guide card word. Subjects were given six examples as practice items and were not allowed to commence the test proper until they understood what was required. Chapman's test has 90 items, and these were divided into three sets on a random basis for each subject. The order in which cards were presented to individual subjects was determined randomly.

For the unpaced condition, subjects were handed the response cards and told to place them appropriately once they had made a decision. Care was taken not to influence the rate at which subjects completed the task under this condition. In order to speed the subjects, the experimenter told them that it was necessary to sort each response card as quickly

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as possible. For the slowed condition subjects were told to deliberate over each decision. Care was taken to ensure that the experimenter did not vary his rate of presenting the guide cards.

It might be suggested that a mechanical method of presenting the stimuli (both guide cards and response cards) would give greater control over operating rates. However, a difficulty with such a method would be that some arbitrary percentage of unpaced time would have to be chosen to determine the speeded and slowed rate and the same percentage change given to all subjects. An optimal increase (or decrease) in rate for one subject may not be at all optimal, in terms of the theory, for other subjects. Furthermore such a procedure would have required that the unpaced condition should come first for all subjects, making it difficult to reject an order effect hypothesis on the basis for changed scores.

Results

Table I shows all subjects' errors classified according to whether the response cards were placed under the associated or the irrelevant guide card words.

The associated errors produced a positively skewed distribution for all subjects, as can be seen by the fact that the means exceeded the medians in all but one case. In association with this the variances were found not to be homogeneous, and so Chapman's practice of analysing the data according to distribution-free statistical models was adopted. Such analyses indicated that the irrelevant errors were not a source of statistically significant differences under any condition.

An analysis of the associative errors, using a Kruskal-Wallis multi-sample test for independent samples (Bradley, 1968), revealed a highly significant 'groups' effect ($H = 35{\cdot}875$; $p < 0{\cdot}001$) for the unpaced condition data. Further analysis by the Mann-Whitney U test (Siegel, 1956) indicated this 'groups' effect to be entirely the result of the poor performance of the schizophrenic group. The schizophrenics did significantly worse than either the inmates ($z = 5{\cdot}132$; $p < 0{\cdot}001$) or the neurotics ($z = 4{\cdot}792$; $p < 0{\cdot}001$), whereas the inmates and neurotics did not differ statistically ($z = 1{\cdot}736$). Since differences in these directions were expected from Chapman's earlier work, the Mann-Whitney analyses were all one-tailed tests.

Considering the changes with speeding in associative errors for the neurotics and the inmates, it was found that both groups made significantly more associative errors under the fast condition compared with their performance when they were allowed to work at their own speed. Using Wilcoxon's Signed-Rank test of difference-scores for related samples (Siegel, 1956), and applying a one-tailed test to the

Table I

Errors on Chapman's task

Groups	Associative errors			Irrelevant errors		
	Unpaced condition	Speeded condition	Slowed condition	Unpaced condition	Speeded condition	Slowed condition
Schizophrenics ..	$\bar{X} = 8{\cdot}33$ Md= 8·00 range = 0 to 18	$\bar{X} = 10{\cdot}43$ Md=10·00 range = 1 to 18	$\bar{X} = 6{\cdot}71$ Md= 5·00 range = 0 to 15	$\bar{X} = 0{\cdot}33$ Md= 0·00 range = 0 to 1	$\bar{X} = 0{\cdot}38$ Md= 0·00 range = 0 to 2	$\bar{X} = 0{\cdot}39$ Md= 0·00 range = 0 to 2
Neurotics ..	$\bar{X} = 1{\cdot}48$ Md= 1·00 range = 0 to 5	$\bar{X} = 2{\cdot}86$ Md= 2·00 range = 0 to 6	—	$\bar{X} = 0{\cdot}38$ Md= 0·00 range = 0 to 1	$\bar{X} = 0{\cdot}38$ Md= 0·00 range = 0 to 2	—
Inmates	$\bar{X} = 0{\cdot}71$ Md= 1·00 range = 0 to 2	$\bar{X} = 3{\cdot}33$ Md= 3·00 range = 0 to 7	—	$\bar{X} = 0{\cdot}24$ Md= 0·00 range = 0 to 1	$\bar{X} = 0{\cdot}29$ Md= 0·00 range = 0 to 1	—

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statistic (the direction of the score change was anticipated from Usdansky and Chapman's (1960) findings), it was found that neurotics made more errors under speeded conditions ($T = 4$; $p < 0{\cdot}005$), and so did the inmates ($T = 3$; $p < 0{\cdot}005$).

Friedman's multi-sample test for related samples (Siegel, 1956) was applied to the associative error data for the schizophrenics under all conditions. The test statistic revealed a significant 'conditions' effect ($\chi^2_r = 24{\cdot}026$; $p < 0{\cdot}001$). Hawks and Marshall's (1971) findings suggested the direction that score changes would take with changes in conditions, so again a one-tailed test was applied to the statistics derived from Wilcoxon's tests. The results indicated that the conditions effect was due to both the speeding and the slowing procedures. The unpaced condition resulted in fewer errors than the speeded condition ($T = 1$; $p < 0{\cdot}005$), and more errors than the slowed condition ($T = 9$; $p < 0{\cdot}005$). The slowed condition produced fewer errors than the speeded condition ($T = 2$; $p < 0{\cdot}005$).

Table II gives the times taken to complete Chapman's task for all subjects under all conditions.

A Kruskal-Wallis multi-sample test revealed a significant 'groups' effect ($H = 8{\cdot}678$; $p < 0{\cdot}02$) for the data under the unpaced condition. A Mann-Whitney U test applied to the differences in time scores between pairs of groups indicated that the overall groups effect for unpaced times was due to the greater speed of the inmates. The inmates were significantly faster than either the schizophrenics ($z = 2{\cdot}440$; $p < 0{\cdot}007$) or the neurotics ($z = 2{\cdot}654$; $p < 0{\cdot}008$), whereas the schizophrenics and the neurotics did not differ statistically) ($z = 0{\cdot}277$). The account of schizophrenic conceptual performance given by Hawks and Marshall (1971) could be considered to imply that the inmates would be faster than the schizophrenics, and so the significance level given in that case is derived from a one-tailed test. The difference between the neurotics and the inmates was not predicted, and so the significance level given in that case is derived from a two-tailed test.

Wilcoxon's test applied to the changes in times with speeding for the neurotics and the inmates indicated significant reductions in the time taken to complete the task (in both cases, $T = 0$; $p < 0{\cdot}005$).

Friedman's test applied to the changes in times with speeding and slowing for the schizophrenic subjects revealed a significant 'conditions' effect ($\chi^2_r = 42{\cdot}00$; $p < 0{\cdot}001$). Further analysis by Wilcoxon's test showed this to be equally due to the slowed and speeded conditions. The speeded condition resulted in faster times than either the unpaced condition ($T = 0$; $p < 0{\cdot}005$) or the slowed condition ($T = 0$; $p < 0{\cdot}005$), and the slowed condition produced an increase in the time taken to complete the task over the unpaced condition ($T = 0$; $p < 0{\cdot}005$).

TABLE II

*Times taken to complete Chapman's task**

Groups	Unpaced conditions	Speeded conditions	Slowed conditions
Schizophrenics	$\bar{X} = 310{\cdot}00$ Md = 318·00 range = 178 to 501	$\bar{X} = 219{\cdot}10$ Md = 181·00 range = 124 to 390	$\bar{X} = 390{\cdot}19$ Md = 405·00 range = 210 to 570
Neurotics	$\bar{X} = 297{\cdot}33$ Md = 292·00 range = 184 to 469	$\bar{X} = 237{\cdot}14$ Md = 222·00 range = 171 to 386	— — —
Inmates	$\bar{X} = 238{\cdot}90$ Md = 222·00 range = 166 to 383	$\bar{X} = 189{\cdot}76$ Md = 182·00 range = 140 to 281	— — —

* Times are all shown in secs.

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Discussion

The results indicate that irrelevant errors on Chapman's test are not a significant souce of differentiation either between the experimental groups under unpaced conditions or within groups across conditions. Associative errors were, however, an important source of difference. Schizophrenics made more associative errors under unpaced conditions than either the inmates or the neurotics, and these errors were increased by speeding the schizophrenics and decreased by slowing them. Both the inmates and the neurotics showed an increase in associative errors under speeded conditions. The findings are consistent with earlier studies. Chapman (1958) found that irrelevant errors did not differentiate schizophrenics from normals, whereas associative errors did. These results were confirmed by other studies (Gonen, 1970; Grimes and McGhie, 1972; Hawks and Marshall, 1971). Usdansky and Chapman (1960) found that speeding normals on this test resulted in an increase in their associative errors, while their irrelevant errors remained unchanged.

The procedures for speeding and slowing were effective in that the times taken to complete the task differed appropriately under the different conditions. Under unpaced conditions schizophrenics did not take longer to complete Chapman's task than neurotics, whereas both of these groups were significantly slower than the inmates.

The effects of speeding and slowing suggest that schizophrenics require more time to process information or to make decisions than other subjects. These findings are not inconsistent with Yates' (1966a, 1966b) theory, except that Yates is only concerned to explain the performance of non-paranoid schizophrenics, whereas the subjects in this study were a mixed group of schizophrenics. The results also agree with Hawks and Marshall's (1971) position. However, an examination of the individual data does not support their contention that schizophrenics can be divided into overinclusive and non-overinclusive on the basis of their performance on Chapman's test. Only one schizophrenic made no associative errors under the unpaced condition, only two made three such errors, four made four errors, and one made six errors. All the rest made eight or more errors. These results are in fact not unlike Hawks and Marshall's findings, and suggest that the term 'non-overinclusive' is inappropriate.

If we consider only those schizophrenics who scored ten or more errors, we will optimize the chances of obtaining support for Hawks and Marshall's argument that slowing should benefit schizophrenics. However two of these sybjects, so far from improving with slowing, actually did worse.

The results, then, offer only limited support for Hawks and Marshall's theory, and the absence of clear results regarding the classification of the schizophrenics' performances into overinclusive and non-overinclusive does not support their assertion that some schizophrenics reduce their errors on concept tasks by slowing their performance. Hawks and Marshall's account, then, appears to be inadequate, and may not even be capable of satisfactory modification.

Summary

Matched groups of schizophrenics, neurotics and penitentiary inmates were tested on Chapman's (1958) concept sorting task under unpaced, speeded and slowed conditions. The schizophrenics made more associative errors under unpaced conditions than the other subjects, and their performance was worsened by speeding and improved by slowing. The neurotics and the inmates also showed an increase in errors when speeded. The results are discussed in terms of Hawks and Marshall's (1971) account of schizophrenics' abnormal conceptual performance. The variations observed in associative errors with changes in operating rates are consistent with Hawks and Marshall's slowed processing theory. However the failure to find a distinction between overinclusive and non-overinclusive subjects within the schizophrenic group detracts from the value of the theory.

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III. The Relationship Between Conceptual Performance and Information Processing Capacities

There have been a number of investigations (e.g. Balken, 1943; Epstein, 1953; Rapaport, 1945; White, 1949; Whiteman, 1954; Zaslow, 1950) aimed at testing Cameron's (1938, 1939) claim that schizophrenics tend to include into their consideration of a problem items that are irrelevant to its solution. Foremost among these studies of 'over-inclusion' have been the work of Payne (Payne, 1960, 1962, 1966; Payne and Hewlett, 1960; Payne, Mattussek and George, 1959) and that of Chapman (Chapman, 1956a, 1956b, 1958, 1961; Chapman and Taylor, 1957).

Payne's methods of assessing overinclusion (Payne and Friedlander, 1962) have been criticized by a number of authors. Hawks (1964) showed that the three tests Payne used did not significantly intercorrelate, nor did they successfully identify schizophrenics within a psychiatric population. Gathercole (1965) has attacked the practice of identifying unusual performance on Payne's tests with Cameron's notion of over-inclusion. He argues that the schizophrenics' performance on these tests could equally well be regarded as a result of fluency of responding. Even if we ignore the suggestion that these tests have severe technical limitations (Foulds *et al.*, 1967; Hawks, 1964; Watson, 1967), it is evident that poor performance on them may be interpreted in different ways.

Chapman's tests have not been subjected to the same technical scrutiny as Payne's, but his results have been independently replicated (Feinberg and Mercer, 1960; Gonen, 1970; Hawks and Marshall, 1971). In the absence of more direct evidence, these findings support the continued use of Chapman's tests, but of course do nothing to validate the interpretation of the results. In fact, it seems improbable that schizophrenics include into their analysis of the problem more of the items appearing on Chapman's test than do other subjects. One version of the test (Chapman, 1958) requires the subject to read three words and then select from them the one that matches a designated word. Under these conditions schizophrenics can hardly be considered to include more items than other subjects.

Payne (1960) claims that the results of studies using 'overinclusion-type' tests, are indicative of the presence in schizophrenics of a defect in the filtering mechanism that normally operates to

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exclude irrelevant input. After considering a variety of evidence, Hawks and Marshall (1971) conclude that slowed processing is the basic problem for schizophrenics and that this produces their relative difficulty on cognitive tasks. It is not clear, however, at what point in a processing system Hawks and Marshall would place this slowness. They mention defective filtering, but also identify their position with Broen's (1968) theory.

Broen (1966, 1968) has suggested that both Payne's and Chapman's findings can be taken to support the view that schizophrenics have difficulties in selecting between responses. He says the problem is that the probability of competing responses has been more nearly equalized in schizophrenics than in normal subjects.

If we consider these arguments within an information-processing model of performance, Payne's (1960) theory would put the difficulty for schizophrenics at the stimulus analysing point in the system, whereas Broen would place the breakdown at the response selection end. As noted earlier, it is not clear where Hawks and Marshall (1971) place the slowed processing. The results of an earlier study (Marshall, 1973a) indicated that schizophrenics had difficulties at both these points but that the response selection problems were of greater magnitude and probably more enduring.

In order to examine the interpretations of the data suggested by Payne, Broen, and Hawks and Marshall, it will be necessary to compare the results of various subjects on one of the concept tests with their performance on an information-processing task. Two earlier studies (Marshall, 1973a, 1973b) examined the performance of the same subjects on Chapman's (1958) test and a choice-reaction-time (CRT) task. The latter task provided the basis for estimating information-processing rates. Correlational analyses of these data would produce the kind of evidence that might help us decide between the various theories.

The implications of the theories mentioned for such correlational analyses differ on some points. Payne would expect stimulus decision times to be correlated with errors on Chapman's test, whereas for Broen to be correct these errors would have to be related to response decision times. Since Hawks and Marshall talk about a general slowing down of processing, presumably they would expect errors on Chapman's test to be related to all the measures derived from CRT performance. They argue that those schizophrenics who slow down their responding will not make errors on concept tasks but will be slow to complete the task. Those schizophrenics who speed their responding, so Hawks and Marshall claim, will make errors on concept tasks. Thus, within the schizophrenic group the time taken to complete Chapman's test should correlate negatively with the number of errors on that test, which should, in turn, correlate negatively with CRT scores. On the other hand, the CRT scores should be positively correlated with the time taken to complete Chapman's test.

Data Analyses

The CRT study produced data which provided the basis for deriving estimates of the movement time involved in completing the task, the time required to make decisions about the stimuli, and the time needed to select between responses.

Performance on Chapman's test was examined under standard conditions for all subjects, and the time taken to complete the test was noted. All subjects were given an additional trial in which they were required to complete the task as fast as they possibly could. The schizophrenics also completed the test under slowed conditions which stressed the importance of making decisions only after the answer was clear.

The groups are described in the earlier studies, and comprised 21 schizophrenics, 21 neurotics, and 21 inmates from local penitentiaries. An additional point to note is that information was collected on age, IQ (Mill Hill Vocabulary), education, and duration of institutionalization. These data will be compared with performance scores.

Results

Spearman's rank-order correlation was used, and Table I shows the resulting matrix for the schizophrenic subjects.

Very few of the correlation coefficients for

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TABLE I

Spearman's rank order correlational matrix for schizophrenics' data

	IQ	Education	Duration of present Hospitalization	Total time spent in hospital	Time since first hospitalization	Associative errors on Chapman's test	Decrease in associative errors with slowing	Increase in associative errors with speeding	Time taken to complete Chapman's test under unpaced conditions	Movement times on reaction-time	Response decision times on reaction-time	Stimulus decision times on reaction-time
Age ..	−0·004	−0·210	−0·170	+0·216	+0·242	+0·499**	+0·421*	−0·545***	+0·025	+0·115	+0·135	+0·233
IQ ..		+0·765#*	+0·026	+0·065	−0·259	−0·014	+0·074	−0·089	+0·053	+0·058	+0·059	+0·053
Education			−0·095	−0·432*	−0·394*	−0·149	+0·106	−0·138	+0·127	−0·122	+0·053	−0·199
Duration of present hospitalization				+0·572#	+0·522***	−0·061	−0·231	+0·203	+0·145	−0·001	−0·070	+0·469*
Total time spent in hospital					+0·954#*	+0·152	+0·071	−0·004	+0·086	+0·274	−0·056	+0·363*
Time since first hospitalization						+0·159	+0·112	−0·024	+0·112	+0·214	−0·091	+0·229
Associative errors on Chapman's test							+0·644#	−0·356	+0·151	+0·760#*	−0·110	+0·224
Decrease in associative errors with slowing								−0·432*	+0·122	+0·645#	−0·073	+0·224
Increase in associative errors with speeding									+0·389*	−0·145	−0·434*	−0·116
Time taken to complete Chapman's test under unpaced conditions										−0·104	−0·862#*	−0·221
Movement times on reaction-time											+0·074	+0·278
Response decision times on reaction-time												+0·196

* $p < 0·05$; ** $p < 0·025$; *** $p < 0·01$; # $p < 0·005$; #* $p < 0·001$.

either the neurotics or the inmates were significant, and it is not necessary to provide the details of all the values calculated. Perhaps the most important observation was that age was significantly correlated both with the associative errors on Chapman's test for the neurotic subjects (rho = 0·53; $p < 0·01$) and with the increase in such errors with speeding for the inmates (rho = 0·40; $p < 0·05$). Taken in conjunction with the findings relating age to associative errors under all conditions for the schizophrenics, these results suggest a confounding age variable in performance on Chapman's test.

The only other significant relationship of any importance was a positive correlation between the duration of present stay in hospital and stimulus decision times for the neurotic subjects.

A separate analysis indicated no significant relationship between paranoid status and either CRT scores or scores on Chapman's test. A similar analysis showed no significant relationship between the presence of delusions and scores on either test. However, delusions and paranoid status were related (r_ϕ = 0·60), the resulting data table revealing a significant deviation from chance ($\chi^2 = 8·06$; $p < 0·02$).

DISCUSSION

The relationship between age and errors on Chapman's test was not observed in previous studies (Grimes and McGhie, 1972; Hawks and Marshall, 1971), and may be an artifact of the present study. However, the fact that for each group a significant relationship was observed between the production of these errors (under one or more of the conditions), and age does reflect on the value of the present findings and more generally reduces the utility of continued use of Chapman's test. The observation by Grimes and McGhie (1972) that schizophrenics' performance on Chapman's test was confounded by intelligence likewise diminishes the value of the test. In fact discussion of the results obtained from this task could stop at this point on the conclusion that Chapman's test, like Payne's, is

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of doubtful technical quality. However, some of the results are worth considering in the light of the theories mentioned earlier.

The absence of significant correlations between errors on Chapman's test and either response or stimulus decision times is contrary to both Payne's (1960) and Broen's (1968) rationalizations of schizophrenics' performance on concept tasks. These same findings added to those showing significant positive correlations between movement times on the CRT task and errors on Chapman's test, also deny Haws and Marshall's (1971) explanation of schizophrenics' abnormal performance. The absence of significant correlations between the time taken to complete Chapman's test and errors on that test is also contrary to predictions from Hawks and Marshall's theory. The significant negative correlation between the time taken to complete Chapman's test under unpaced conditions and response decision times is similarly opposite to expectations from Hawks and Marshall's account. Finding no relationship between their measure of speed (Babcock's (1941) digit copying task) and errors on Chapman's test, Hawks and Marshall suggested that the time taken to complete Chapman's test might represent a measure of 'mental speed'. Presumably mental speed describes some aspect of processing. If they were correct then the time taken to complete Chapman's test should correlate positively with either stimulus or response decision times. The results for the schizophrenic subjects deny this claim.

There has been some disagreement on the matter of which subgroup of schizophrenics is most affected by disturbed processing (for a discussion of this issue see McGhie, 1970). Payne (Payne, 1960; Payne *et al.*, 1963) claims that acute schizophrenics are overinclusive (and, by implication, have a defective filter mechanism), whereas chronic patients are not. McGhie's (1966) research indicates that the acute/chronic dimension is irrelevant to observing distraction effects. The significant positive correlation between schizophrenics' stimulus decision times and both present and total time in hospital suggests that chronicity is related to increasing difficulties in analysing stimuli. Duration of stay in hospital is of course only one index of chronicity and may be disputed as an adequate measure. The results not only tend to deny McGhie's claim that chronicity is irrelevant, they also suggest that the reverse of Payne's argument may be true; that is, chronic (or long-term) schizophrenics may have defective filtering while acutes may not.

The absence of significant correlations between movement time and response and stimulus decision times suggests that, at least on the CRT tasks used in the present study, speed of functioning is not a unitary trait among schizophrenics. Earlier studies disagreed on this point (Payne and Hewlett, 1960; Shapiro and Nelson, 1955).

The analyses relating to paranoid status and the presence of delusions failed to support the popular claim (Lawson, 1965; Lawson, McGhie and Chapman, 1964; Payne, 1960; Payne, Caird and Laverty, 1964) that these clinical characteristics are relevant to discerning performance defects in a schizophrenic population.

The results, then, do not offer support for any of the theories considered that attempt to explain schizophrenics' abnormal performance on concept tasks. Perhaps the findings are simply the result of an age-confounding factor in performance on Chapman's test. There is evidence (Payne, 1971) to suggest that most, if not all, concept tests that have been scrutinized have technical flaws. In addition, performance on conceptual tasks is difficult to interpret, and it is a large, and somewhat unwarranted, inferential step to posit information processing difficulties as basic to poor performance on such tasks. For these reasons it is recommended that further studies should abandon the use of concept tasks as research instruments. In any case, since much of research interest now focuses on the information processing capacities of schizophrenics, it would be as well to use more direct tests of such abilities. CRT tasks not only provide simple well controlled procedures which schizophrenics can follow with a minimum of difficulty, they also permit the researcher to apply well tested models for the analysis and elucidation of various aspects of processing. Further data relating to schizophrenics' CRTs would allow a more adequate description of schizophrenics' information-processing capa-

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cities and may provide the basis for a more useful theory of such patients' general functioning.

Summary

A number of theories suggest a relationship between schizophrenics' performance on concept tasks and the information-processing capacities of these patients. The present study describes correlational analyses of earlier data obtained from schizophrenics, neurotics and penitentiary inmates. The relationship between choice-reaction-time (CRT) data and scores on Chapman's concept sorting test is examined and the results discussed in terms of various theories. The findings offer no support for either Payne's or Broen's rationalizations of schizophrenics' concept task performance, nor do they agree with any of the deductions from Hawks and Marshall's theory. The evidence is taken to indicate the lack of utility of concept tests, and it is suggested that research energies be focused on more direct methods of assessing information-processing. CRT tasks provide such relatively direct methods.

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W. L. Marshall, M.Sc., B.Psych., Ph.D., *Psychologist, Clinical Psychology Laboratory, Kingston Psychiatric Hospital, Kingston, Ontario, Canada*

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