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Errorless learning and memory performance in schizophrenia

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Abstract

There is evidence that patients with schizophrenia have impaired explicit memory and intact implicit memory. The present study sought to replicate and extend that of O'Carroll et al. [O'Carroll, R.E., Russell, H.H., Lawrie, S.M. and Johnstone, E.C., 1999. Errorless learning and the cognitive rehabilitation of memory-impaired schizophrenic patients. *Psychological Medicine* 29, 105–112.] which reported that for memory-impaired patients with schizophrenia performance on a (cued) word recall task is enhanced using errorless learning techniques (in which errors are prevented during learning) compared to errorful learning (the traditional trial-and-error approach). Thirty patients with a DSM-IV diagnosis of schizophrenia and fifteen healthy controls (HC) participated. The Rivermead Behavioural Memory Test was administered and from their scores, the schizophrenic patients were classified as either memory-impaired (MIS), or memory-unimpaired (MUS). During the training phase two lists of words were learned separately, one using the errorless learning approach and the other using an errorful approach. Subjects were then tested for their recall of the words using cued recall. After errorful learning training, performance on word recall for the MIS group was impaired compared to the MUS and HC groups. However, after errorless learning training, no significant differences in performance were found between the three groups. Errorless learning may play an important role in remediation of cognitive deficits for patients with schizophrenia.

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1. Introduction

There is now a significant body of research to support the existence of memory deficits in patients with schizophrenia. Memory and learning functions are more seriously disturbed than general intellectual function (Tamlyn et al., 1992), including in unmedicated

and first episode patients (Saykin et al., 1991, 1994). The nature of the memory impairments in schizophrenia is thought to be similar to that observed in patients with organic amnesia, in that explicit memory is impaired whereas implicit memory remains intact (Duffy and O'Carroll, 1994; Dominey and Georgieff, 1997; Rushe et al., 1999).

Cognitive rehabilitation is one approach to treatment of organic amnesia. A technique which has achieved a measure of success recently involves the application of errorless learning (Terrace, 1966). Errorless learning techniques prevent subjects from making errors during a

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learning phase and contrast with the traditional the trial and error approach. Wilson et al. (1994) have conducted a number of studies employing the errorless learning procedure. In their first, subjects with severe memory impairments were trained to recall word lists, using a cued recall design whereby the first two letters of a word are presented and the task is to recall the correct word. During the training phase, one list was presented to ensure errors were made during learning, i.e. the trial and error approach: subjects were given the first two letters of the word and were told to guess what that word was. During errorless learning, subjects were given the first two letters of a word and then told what that word was. The results showed that after errorless learning, more words were recalled from the list of words than from the list of words learned using errorful learning. The benefits of errorless learning were also found to facilitate improved learning of everyday tasks, such as programming an electronic aid (Wilson et al., 1994).

1.1. Cognitive rehabilitation in schizophrenia

Cognitive deficits influence current and future social functioning of schizophrenic patients (Wykes and Dunn, 1992; Buchanan et al., 1994; Green, 1996), though only recently have cognitive impairments become a focus for therapeutic intervention. The goal of the remedial approach is to improve social functioning, and to some extent clinical symptoms, by attempting to ameliorate cognitive deficits (Wykes et al., 1999).

One of the principles of cognitive rehabilitation programmes is the utilisation of preserved cognitive operations. For example, in patients with organic amnesia, the advantage of errorless learning has been explained because it maximises the preserved implicit memory system (Baddeley and Wilson, 1994).

Errorless learning methods have been applied with a measure of success in remediating Wisconsin Card Sorting Test deficits in a group of chronic psychotic patients (Kern et al., 1996). They attempted to determine the effect of previously committed errors on training and post-training performance, but their findings were inconclusive. Subsequently Wykes et al. (1999) carried out an intensive programme, similar to an errorless learning technique, in patients with schizophrenia, involving daily sessions of 1 h for up to 3 months, and showed that those patients with demonstrable deficits benefited compared to those patients who underwent traditional occupational therapy programmes.

This present study aims to replicate and extend the work of O'Carroll et al. (1999), who examined errorless learning in a group of sixty-five patients with schizo-

phrenia. They employed a similar methodology to Wilson et al. (1994), comparing errorful learning and errorless learning on subsequent recall of word lists. O'Carroll et al. (1999) report a clear advantage of errorless learning, indicating that when memory-impaired patients with schizophrenia are prevented from guessing and making errors during learning, their memory performance is improved. Additionally, test performance following the errorful learning approach was significantly poorer for the memory-impaired group only, suggesting that the traditional trial and error method may be particularly detrimental for this group.

Following O'Carroll et al. (1999) and Baddeley and Wilson (1994), the word stem completion task was employed in this study. The procedure differed from that of O'Carroll et al. (1999) in that more extensive measures of memory functioning (full version of the Rivermead Behavioural Memory Test (RBMT) (Wilson et al., 1985) and IQ (shortened version of the WAIS-R (Canavan et al., 1986)) were taken in order to explore more closely the effects of errorless learning in patients with severe-moderate memory impairment. O'Carroll et al. (1999) employed an abbreviated version of the RBMT, so the standardised classification system could not be applied to their subjects performance. It was hypothesised that memory-impaired patients with schizophrenia would perform significantly better on recall following the errorless learning condition than following the errorful learning condition.

2. Method

2.1. Subjects

This study involved thirty patients with a diagnosis of schizophrenia according to DSM-IV criteria. They were recruited from a psychiatric day hospital ($n=28$) and an acute ward ($n=2$) maintained by Homefirst Community Health and Social Services Trust, Northern Ireland. Those subjects with a history of organic brain disease, head injury, significant drug or alcohol abuse or an IQ score of less than seventy were excluded. Patients who had received electroconvulsive therapy within the previous twelve months and those who were taking a daily dose of anticholinergic medication exceeding 20 mg of procyclidine or its equivalent were also excluded. The patients were not already participating in a cognitive rehabilitation programme. Fifteen healthy control participants (with no history of psychiatric illness) were recruited from the general public. Participation was entirely voluntary (all subjects provided written, informed consent) and subjects were tested in

one individual session. The study received full approval from the local research ethics committee.

2.2. Memory functioning

The Rivermead Behavioural Memory Test (RBMT, Wilson et al., 1985) was used to subdivide patients into two groups according to their memory performance. The RBMT was chosen as it has been reported to provide “an ecologically valid” measure of everyday memory functioning (Wilson et al., 1989) and is suitable for use in clinical populations, not making too many demands on attention and motivation (McKenna et al., 1995). The full version of the RBMT was administered to give a thorough measure of the patients’ memory ability. The RBMT includes tests of picture recognition, face recognition, immediate and delayed story and name recall, immediate and delayed route memory, spatial memory, orientation and prospective memory (i.e. remembering to do things at a future time). These subtest scores were converted to standardised profile scores (0, 1 or 2), giving a possible profile score range of 0–24 (classification by profile score: 0–9=severely impaired; 10–16=moderately impaired; 17–21=poor memory; 22–24=normal).

All subjects were administered the shortened version of the Wechsler Adult Intelligence Scale (Revised; WAIS-R, (Canavan et al., 1986), from which prorated scores for Full-Scale IQ were derived. The patients’ clinical state was assessed using the Krawiecka Psychiatric Assessment Scale (Krawiecka et al., 1977).

2.3. Experimental procedure training (learning) trials

A stem completion task was used where subjects were given the first two letters of a five letter word and their task was to produce the target word. Two separate lists were constructed, to assess recall under the two different learning conditions, and it was ensured that no two target words had the same initial letter pair. In order to avoid ceiling effects, this present study follows the procedure used by O’Carroll et al. (1999) in that the patients learned lists of seven words for each learning condition, whereas controls learned lists of ten words. Each word list was presented three times for each condition.

2.3.1. Errorless learning

In the errorless learning condition the subject is given the first two letters, then told the target word and asked to write it down (for example, “I am thinking of a five letter word beginning with the letters ST and that word is

START. Please write that word down now”). This procedure was repeated for each word on the list, and then repeated for the entire list for each of the three learning trials, using the same instructions. Target words were presented in random order in the second and third learning trial to control for recency and primacy learning effects.

2.3.2. Errorful learning

For the errorful learning condition subjects were given the first two letters of a five letter word and asked to guess what that word was (for example, “I am thinking of a five letter word beginning with ST, can you guess what it is?”). The subject was allowed to give four guesses before the tester provided the correct target word from the list. If 25 s passed where the subject did not offer a guess, the target word was then provided. Thus the subject might guess STING, STORM, STARK and STOOL, after which the tester would reply “No, those are good guesses but the word I am thinking of is START. Please write that word down now”. If the subject guessed the target word first time, a new word was substituted to ensure errorful learning would occur. Subjects underwent three learning trials each involving the presentation of the entire word list.

2.3.3. Testing phase

After the learning phase subjects were given nine test trials divided into three blocks of three trials. A five-minute break was allowed between blocks one and two. For each word, the tester told the subject the first two letters of the target word and the subject was asked if they could remember the correct word (i.e. “One of the words that you wrote down began with the letter ST, can you remember what it is?”). Subjects were encouraged to give any appropriate word if they did not initially respond. If the subject did not give any answer after 25 s, it was assumed that the word had been forgotten and an incorrect response was recorded. In this testing phase, the tester provided the target word when subjects gave incorrect answers. This procedure was used for memory testing on all trials in both conditions. The experiment employed a counterbalancing of condition presentation and subjects participated in both errorless learning (EL) and errorful learning (EF) and testing in the same session, with each condition being separated by a ten-minute break. In order to facilitate direct comparison of performance across the group with different numbers of words to be recalled (10 for the control group and 7 for schizophrenic patients groups) the total number of correct responses for each testing trial was recorded as a percentage of the total number of words.

Table 1

Means, standard deviations and statistical analysis results for IQ and memory functioning for the three groups

(1,28)	Memory-impaired Schizophrenia (N=12)	Memory-unimpaired Schizophrenia (N=18)	Controls	F (N=15)	P df
RBMT	13.8 (2.7)	20.8 (2.1)	23.3 (0.1)	79.4	<0.001
FSIQ	89.8 (13.5)	92.7 (10.7)	111.2 (10.5)	15.0	<0.001

Key: RBMT=Rivermead Behavioural Memory Test; FSIQ=Full scale IQ (WAIS-R).

(Note: means are given with the standard deviation in parenthesis).

Subscales of the WAIS-R were administered during this ten-minute break and also during the five-minute time lapses before delayed recall testing in the testing phase. This design was used to eliminate any opportunity for rehearsal of target words. Subjects were given a ten-minute break before the administration of the RBMT towards the end of the session. The RBMT was administered last to control for experimenter bias, as the experimenter was blind to subject grouping in the patients during training and testing of both conditions. The interview for the Krawiecka Scale was conducted by a senior psychiatrist within 1 week of the subject's participation in the experimental procedure.

2.4. Data analysis

Separate repeated measures analysis of variance (ANOVA) were carried out on the percentage correct scores on each trial for each of the three groups after the EL and then the EF conditions, with group (memory-unimpaired schizophrenic (MUS), memory-impaired schizophrenic (MIS), healthy controls (HC)) as the between group factors and Trial Number (1–9) as the within group factors. Post hoc analyses using the Fischer's protected Least Significant Differences Test were conducted to test separate group differences. Additional repeated measures ANOVA were carried out using full-scale IQ as a covariate, in order to control for any confounding effects. Univariate analysis of variance and Chi-square tests were used to examine differences between groups on socio-demographic and clinical variables.

3. Results

3.1. Description of sample

Subjects were classified as belonging to the memory-impaired schizophrenic (MIS) group if they scored 16 or under on the RBMT (moderately impaired or severely impaired memory). This memory-impaired group totalled 12 patients. The remaining 18 patients obtained scores between 16 and 24, thus falling into the poor memory or

normal memory functioning categories and formed the memory-unimpaired schizophrenic group (MUS). The healthy control group (HC) were recruited from the general population and scored between 21 and 24 on the RBMT (falling into the poor memory and normal memory categories). Univariate analysis of variance showed significant differences between the groups for RBMT scores (Table 1). Post hoc analysis using Fischer's protected Least Significant Differences test revealed that controls scored higher than the MIS group (mean difference=9.5, $P<0.0001$) and the MUS group (mean difference=2.5, $P=0.001$). The MUS group also scored higher than the MIS group (mean difference=7.0, $P<0.0001$).

Post hoc analysis using Fischer's protected Least Significant Differences tests showed that controls had a higher Full-scale IQ than both the MUS (mean difference=21.45, $P<0.0001$) and the MIS group (mean difference=18.48, $P<0.0001$), but the two patient groups did not differ with respect to Full Scale IQ (Table 1). Full score IQ was used as a covariate in the analysis of between group differences on subjects' word recall scores.

Socio-economic status (SES) was measured by father's occupation during the subject's childhood and was assessed according to the Office of Population Censuses and Surveys (OPCS) classification of occupations (1=professional, 2=intermediate, 3=skilled, 4=semi-skilled and 5=unemployed). In order to generate sufficient cell numbers required for the Chi-square test, this classification system was further collapsed such that group one in the present study corresponds to groups 1, 2 and 3 of the OPCS and group two corresponds to groups 4 and 5 of the OPCS. The three groups did not differ in terms of age, socio-economic status, gender balance or on handedness (see Table 2). Significant differences were found for alcohol consumption with the healthy controls drinking the most per week and the memory-unimpaired schizophrenic group drinking more per week than the memory-impaired group. A significant difference between the three groups was also found for the number of years spent in education. The years in education variable was not used as a covariate as it was found to be highly correlated to full scale IQ (Pearson's correlation $r=0.65$,

Table 2
Socio-demographic and clinical characteristics of the three groups

	Memory-impaired Schizophrenia (N=12)	Memory-unimpaired Schizophrenia (N=18)	Controls (N=15)		P
Age	42.6 (13.3)	36.1 (10.2)	31.4 (13.2)	$F=2.9$	0.07
Education	11.6 (2.1)	11.4 (1.4)	14.5 (3.6)	$F=7.1$	0.002
Alcohol	0.8 (1.8)	8.2 (9.6)	14.5 (7.8)	$F=10.7$	<0.001
Sex (m/f)	83%/17%	72%/28%	53%/47%	$\chi^2=2.9$	0.23
Handedness (r/l)	83%/17%	72%/28%	87%/13%	$\chi^2=1.2$	0.56
SES (1/2)	58%/42%	56%/44%	53%/47%	$\chi^2=0.1$	0.97
Medication type (typ/atyp/mix)	25%/58%/17%	33%/61%/6%	–	$\chi^2=1.1$	0.59
Procyclidine (yes/no)	17%/83%	44%/56%	–	$\chi^2=2.5$	0.11
Chronicity (months)	100.3 (56.12)	99.1 (78.3)	–	$F=0.002$	0.97
Age at onset (years)	26.3 (40.1)	23.7 (31.3)	–	$F=2.8$	0.11
Positive symptoms	1.42 (1.41)	1.33 (0.83)	–	$F=0.07$	0.80
Negative symptoms	2.03 (0.67)	1.23 (0.49)	–	$F=14.51$	0.001

Key: Education=mean number of years spent in education; alcohol=mean units per week; SES=socio-economic status (upper 1 and lower 2); Medication type: typical, atypical or mixed; Chronicity=months since first hospital admission; Age at onset=age in years when first admitted. (Note: means are given with the standard deviation in parenthesis); positive and negative symptoms from Krawiecka Scale.

$P=0.01$) and was assumed to have similar confounding effects to IQ score.

There was no significant difference between the patient groups for positive symptoms, but the memory-impaired patients had significantly higher ratings for negative symptoms than the memory-unimpaired group (Table 2). In order to test the possibility that the increase in negative symptoms in the MIS accounted for the differences in memory performance between the two patients groups, the RBMT scores for the MIS and MUS were re-analysed controlling for negative symptoms. The significant difference between the groups was upheld.

Eleven patients were taking anticholinergic drugs (ten procyclidine at a mean daily dosage of 10.5 mg (range 5 mg–15 mg) and one benztropine 2 mg daily). No significant difference was found between the proportions of patients from each group taking procyclidine ($\chi^2=2.5$, $df=1$, $P=0.11$).¹ There were no significant differences between the proportions of patients taking typical, atypical or mixed medication type in each group (see footnote).

Duration of illness was taken as the time elapsed between the first recorded hospital admission and the date of testing. No significant differences were found between the MIS group and the MUS group. The

difference between the groups for age at the onset of their illness was also non-significant (Table 2).

3.2. Errorful learning

The three groups mean performance on all nine trials are presented in Fig. 1 (errorful learning) and Fig. 2 (errorless learning). For the EL condition, a significant main effect was found for the group ($F(2,42)=9.1$, $P=0.001$). Fischer's protected Least Significant Differences (LSD) test showed significant mean differences between the groups, with the MIS group performing worse than the HC group (mean difference=10.9, $P<0.001$), and the MUS group (mean difference=9.9, $P<0.0001$). There was no significant difference between the performance of the HC and the MUS groups.

Fig. 1. Recall after errorful learning.

¹ Thirteen patients were taking typical antipsychotics (five chlorpromazine, four clopexol, two depixol, and two haloperidol) and twenty-two were taking atypical antipsychotics (five clozapine, six risperidone, four amisulpride, six olanzapine and one quetiapine). Three patients were taking both typical and atypical medication concurrently.

Fig. 2. Recall after errorless learning.

A significant main effect for trial was also found ($F(2,42)=176.4$, $P<0.001$), which suggests that performance differed with respect to trial number (see Fig. 1). There was substantial forgetting at trials 4 and 7 (i.e. testing after the 5 min and 10 min breaks respectively) for both conditions. However, significant interaction effects for trial by group ($F(2,42)=7.2$, $P=0.02$) were also found, demonstrating that the effects of trial number were not the same for all groups.

When full-scale IQ (FSIQ) was controlled for, the significant main effect for group was maintained for the EF condition ($F(2,1,41)=6.4$, $P=0.004$). The significant effects for trial ($F(1,1,41)=4.68$, $P=0.036$) and for trial by group interaction ($F(2,41)=6.26$, $P=0.004$) were also maintained when FSIQ was taken into account.

3.3. Errorless learning

For the EL learning condition the effect of group was not significant ($F(2,42)=3.1$, $P=0.054$).

Post hoc analysis using Fischer's protected Least Significant Differences Test showed that while the HC group performed significantly better than the MIS group, the MIS was not significantly worse than the MUS group (mean difference=3.8, $P=0.09$). There was no significant difference between the HC and the MUS group (mean difference=1.8, $P=0.2$).

A main effect was found for trial ($F(1,42)=23.8$, $P<0.001$), again showing that subjects' performance was related to trial number (Fig. 1). The trial by group interaction was significant ($F(2,42)=5.5$, $P=0.008$), suggesting that the effect of trial was not constant for all groups.

For the EL learning condition, when controlling for FSIQ, there was no significant difference between groups for memory performance across trials ($F(2,1,41)=1.4$, $P=0.25$). The main effect of trial is not maintained

($F(1,1,41)=3.2$, $P=0.08$) but the significant trial by group interaction is upheld ($F(2,41)=3.9$, $P=0.026$).

4. Discussion

In this study the memory-impaired schizophrenic patient (MIS) group performed at a rate comparable to that of the memory-unimpaired (MUS) group on the word recall task after EL learning. After EF learning the MIS group performed significantly worse than both the MUS and the control group. Thus these results suggest that when memory-impaired patients with schizophrenia are prevented from making errors during learning, their memory performance is significantly improved, even when their memory impairment is classified as moderate to severe.

4.1. Possible confounding variables

The advantage of EL over EF learning for the MIS group demonstrated here cannot be accounted for by the possible influence of confounding variables. There were no significant differences between the three groups in terms of age, sex, handedness and socio-economic status, or between the two patient groups in terms of medication, duration of illness or age of onset. Differences in alcohol consumption could not have influenced the memory performance of the MIS group as the MUS and control groups drank more alcohol on average than the MIS group. Ratings on the Krawiecka Scale showed that the MIS group experienced significantly more negative symptoms than the MUS group, but even after controlling for negative symptoms in a covariate analysis, the MIS group still performed significantly less well than the MUS group on baseline memory testing. Thus the memory deficit in the MIS group is not simply due to the greater prominence of negative symptoms.

Controls learned list of 10 words whereas patients learned lists of 7 words in an attempt to avoid ceiling effects (as in the studies reported by O'Carroll et al. (1999) and Baddeley and Wilson (1994)). A limitation of this practice, however, is that performance in terms of percentage correct between the healthy control group and the two patients groups are not directly comparable. In addition, the learning experience is not directly comparable with a differential load of processing across the groups. However, the two patients groups learned word lists of equal length, so their learning experience and performance are directly comparable. As such the main conclusion of this study; that in contrast to the trial and error approach, errorless learning brings the performance of memory-impaired patients with

schizophrenia in line with that of memory-unimpaired patients, is valid.

The differences between the groups on IQ scores do not explain why errorless learning facilitates improved memory performance, as the main effect of word recall for the MIS group was maintained after controlling for full-scale IQ. Similarly, as the number of years spent in education was correlated to full-scale IQ scores, it does not appear to influence the main findings of the study. Effects of experimenter bias can be ruled out as subjects were grouped according to memory function after the experimental learning procedure had been conducted.

4.2. *How do we explain the errorless learning advantage?*

A number of studies (Clare et al., 1993; Rushe et al., 1999) have described finding preserved implicit memory but impaired explicit memory in patients with schizophrenia. The MIS group in this study may have relied on their preserved implicit memory when performing the stem completion task. As the implicit memory system is not thought to deal well with errors (Baddeley, 1992), in the EL condition in which errors were encouraged, the memory-impaired patients' incorrect guesses may have been remembered implicitly (Baddeley, 1992). This explanation may account for the slower rate of learning across trials for the MIS group after EL learning, in that the testing phase also includes learning because incorrect responses are corrected by the experimenter. Thus, errors were also introduced in the testing phase after errorless learning. It would be useful to incorporate analysis of participants' errors, both during the learning and testing phase, in order to test the hypothesis that memory-impaired subjects are more prone to making such intrusion errors.

Further research needs to be carried out in order to investigate whether errorless learning in patients with schizophrenia is dependent on implicit memory or whether explicit memory is also involved. This could involve incorporating items such as the fragment completion task used by Hunkin et al. (1998) into the testing procedure, in order to explore the relationship between errorless learning and implicit memory. Additionally, other measures might be employed to measure explicit memory (e.g. free recall of learned material) and implicit memory functioning (e.g. pursuit rotor task, Tower of Hanoi task).

Hunkin et al. (1998) have provided evidence that improvements on EL learning is not correlated with preserved implicit memory. Learning using EL learning gave rise to higher levels of cued recall and resulted in

significantly higher levels of free recall. These benefits were maintained across a 48-hour delay, but there was a significant decrement in performance across the delay in the EL learning condition only. The authors argue that if we assume that performance in both EF and EL conditions is dependent on implicit learning, similar rates of forgetting in the two conditions would be expected to occur. They argue that the assumption that responses made following EL learning are based on implicit memory is also challenged by their finding that EL learning resulted in greater free recall. Free recall has been established as depending on explicit memory. The authors suggest either that explicit responses depend to some extent on implicit memory or that information acquired by implicit memory is somehow transferable for subsequent access by explicit memory.

Baddeley and Wilson (1994) considered the possibility that proactive interference may account for errors on the task—forgetting may result from the disruption of new learning by previously learned material (Warrington and Weiskrantz, 1978). If this were the case, the encouragement to generate incorrect responses in the learning phase of the EF learning condition would set up strong competing items which would be suppressed during the process of learning the correct response. Such previously learned erroneous responses recover spontaneously over time and subsequently begin to compete with and possibly supplant the correct response.

Evans et al. (2000) suggest that an alternative explanation for the advantage of EL learning is that it supports residual explicit memory processes. In the present study, the MIS group of patients were moderately or severely memory-impaired, but would be expected to have some explicit memory capacity, which may have been sufficient to deal the task under the EL learning conditions.

A final hypothesis for the advantages of errorless learning in schizophrenia has been offered by O'Carroll et al. (1999). Patients with schizophrenia (Vinogradov et al., 1997) and patients with frontal lobe lesions (Janowsky et al., 1989) experience difficulty in differentiating self-generated from externally generated stimuli after a time delay. In the learning phase of the EF condition, subjects made incorrect guesses and the correct answer was then provided by the experimenter. Thus, the experimenter was the first source of correct answers. O'Carroll et al. (1999) suggest that as a result of such source monitoring difficulties, memory-impaired schizophrenic patients in the EF learning condition lacked the ability in determining whether the correct answer was one which they themselves generated or whether it had been generated by the experimenter.

4.3. Limitations and implication of the study

This study illustrates that errorless learning improves learning of new material in people with schizophrenia. While O'Carroll et al. (1999) report similar results, the present study adopted more extensive measures of IQ and memory functioning. Subjects were administered the shortened version of the WAIS-R from which prorated IQ scores were calculated (Canavan et al., 1986), whereas O'Carroll et al. (1999) assessed subject's IQ levels using the Quick IQ test. The full version of the RBMT was used to assess patient's memory functioning in this study, while an abbreviated form of the RBMT, consisting of three out of a possible eleven subtests, was used by O'Carroll et al. (1999). Additionally, in O'Carroll et al.'s study (1999) patients were deemed as having memory impairment if their performance fell below the range of normal control performance on the RBMT whereas in this study patients were classified as being memory-impaired if they met the criteria for moderate or severe memory impairment on the RBMT (i.e. profile scores of 16 or less). Therefore, the results of this study provide a more conclusive demonstration of the effectiveness of errorless learning training techniques in patients with schizophrenia and severe–moderate memory impairment.

It is not known whether the effects of errorless and errorful learning in schizophrenia are durable. It is clear from the pattern of results that substantial forgetting was experienced by the memory-impaired group on recall five and 10 min after the word list had initially been learned. Wilson et al. (1994) reported that retention following errorless learning can last over a prolonged period of time and Kern et al. (1996) found that improvements made by patients with chronic schizophrenia following errorless learning training on the WCST were maintained at a four-week follow-up. In contrast, when Hunkin et al. (1998) tested recall of amnesic patients on word lists learning after a delay of 48 h, they reported significant levels of forgetting in the errorless learning condition.

An important implication for future research is the lack of generalisability of the task used (learning word lists) to more real life, practical tasks. In order for errorless learning methods to be applicable to rehabilitation programmes for schizophrenia, they must be able to incorporate memory training for relevant everyday tasks (such as programming the alarm of an electronic organiser to remind a patient to take his/her medication). Kern et al. (2002, 2003, 2005) have demonstrated the superiority of errorless learning over trial and error techniques in schizophrenia in the area of work rehabilitation and social problem solving. Eyler et al. (2005) on the other hand

found no benefit for errorless learning when used to improve understanding of informed consent in patients with schizophrenia. Evans et al. (2000) found errorless learning to be beneficial to practical tasks that relied on implicit memory but not to performance on tasks which required explicit recall of novel associations.

Errorless learning has been criticised for its passive learning approach. Some studies have reported expanding errorless learning procedures, incorporating other variables such as 'effort' into the experimental procedure in order to attempt to maximise learning ability. In some of their experiments Evans et al. (2000) employed a backward chaining technique. This method was compared to the more passive form of errorless learning and to the trial-and-error approach. Results showed that while both types of errorless learning facilitated superior learning than the trial-and-error method, no advantage was found for the backward chaining methods over standard errorless learning. Future studies in schizophrenia could investigate the importance of the effort factor in errorless learning.

In conclusion, errorless learning has facilitated improved memory performance in comparison to the more traditional 'trial and error' learning method with severe–moderately memory-impaired patients with schizophrenia. Thus, the use of errorless learning methods as cognitive rehabilitation strategies for schizophrenia is worthy of further investigation.

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