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A TRAINING PROCEDURE FOR REMEDIATING WCST DEFICITS IN CHRONIC PSYCHOTIC PATIENTS: AN ADAPTATION OF ERRORLESS LEARNING PRINCIPLES

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Summary—Although a number of studies have demonstrated that psychiatric patients' performance deficits on the Wisconsin Card Sorting Test (WCST) can be modified through intervention, relatively little evidence exists to support the long-term durability of training effects. The present study tested the effectiveness and durability of a training procedure based on errorless learning principles, and in addition sought to determine the effect of previously committed errors on training and post-training performance. Twenty-three chronic psychotic inpatients were randomly assigned to an Initial Error ($n=11$) or No Initial Error ($n=12$) group. The Initial Error group received two standard administrations of the WCST prior to training (where they were expected to commit many errors); the No Initial Error group had no prior exposure to the WCST. All subjects received training on the WCST which was followed by immediate, 1-, 2-, and 4-week post-tests. Results supported the effectiveness of training and the durability of effects, but previous error history showed no clear relationship to post-training performance. Copyright © 1996 Elsevier Science Ltd.

Introduction

The Wisconsin Card Sorting Test (WCST) is a widely used neuropsychological test that has drawn considerable investigative attention since its introduction to the literature in 1948, largely because of its putative sensitivity to frontal lobe dysfunction (Milner, 1963). It is well established that both schizophrenia patients in particular and chronic psychotic patients in general show deficits on this test relative to normal adults, a pattern typically characterized by a reduced number of categories achieved and elevated number of perseverative errors (Beatty et al., 1994; Braff et al., 1991; Green et al., 1992; Goldman et al., 1992). Several investigators have attempted to ameliorate the deficit by using a variety of training interventions that have included explicit instruction, contingent reinforcement, or a combination of both. Although the majority of studies have found that the performance deficits can be modified, the results concerning the durability of these gains are equivocal, at best.

From a different body of literature there is a teaching approach that has been shown to yield persistent gains in performance long after the completion of training. This approach,

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errorless learning, is derived from the animal studies of errorless discrimination training conducted by Terrace (1966). Errorless training of the type employed in clinical treatment is based on carrying the desired response through a series of incremental changes in task demands. Training begins on tasks where there is a high expectation for the desired response to occur, and proceeds step-wise through a series of exercises in which the task demands are made more difficult. High levels of performance are maintained at each stage because of the minute alterations in task difficulty. This procedure stands in marked contrast to programmed instructional techniques that have generally been used in studies of the WCST with schizophrenia patients, in which subjects are provided key information about the task and then told how to respond, or provided small amounts of money as reinforcement for correct responses. Errorless learning has been used with the developmentally disabled for teaching new skills and curbing behavioral problems (Ducharme et al., 1994; Lancioni & Smeets, 1986; Stoddard & Sidman, 1967; Touchette & Howard, 1984), and has recently been explored as an avenue for remediating cognitive deficits in patients with neurological disorders (Baddeley, 1992; Wilson, 1992).

Laboratory-based studies that have used errorless learning procedures have shown that the commission of errors prior to training affects post-training performance under certain training conditions. For example, in one study a small group of severely mentally retarded boys who attempted to learn a discrimination task through trial-and-error learning prior to errorless training had poorer durability compared to subjects who had no trial-and-error history with the task (Touchette, 1968). It is unknown whether or not the commission of errors on the WCST prior to training would affect post-training performance.

The current study: (a) tested the effectiveness of a WCST training procedure designed to minimize errors committed during training; (b) tested the durability of performance gains; and (c) tested the effects of previously-committed errors on WCST performance during and after training.

Method

Subjects

Thirty-four chronically mentally ill inpatients from the acute and chronic psychiatric inpatient units at Camarillo State Hospital participated in the study, based on preselected exclusion criteria. All patients were under conservatorship at the time of the study and were not involved in any other research studies at the time of their participation. Exclusion criteria included: (a) history of mental retardation; (b) age greater than 50 years; and (c) history of alcohol or substance abuse within the past 6 months. Patients who were not excluded on the basis of the above criteria were then randomly assigned to one of two groups (Initial Error (IE) vs No Initial Error (NIE)). After a complete description of the study was provided, written informed consent was obtained from all subjects. In addition to the above exclusion criteria, patients were also excluded on the basis of two performance criteria: (a) failure to pass an initial screening measure that required the identification of WCST stimulus features on a small sample of WCST cards ($n = 7$); and (b) failure to pass performance criteria during training ($n = 4$). Table 1 presents the mean age, education, ethnicity, chronicity measures, Brief Psychiatric Rating Scale (BPRS) scores, and current

Table 1
Demographic Characteristics for Initial Error (IE) and No Initial Error (NIE) Groups

	Initial Error (*n* = 11)	No Initial Error group (*n* = 12)
Age		
M	33.2	30.1
SD	7.2	8.0
Range	(18–41)	(19–43)
Education		
M	11.2	11.7
SD	1.7	1.7
Range	(7–13)	(8–14)
Ethinicity (percent of group)		
Caucasian	90.9	50.0
African-American	9.1	16.7
Latino	0.0	8.3
Asian	0.0	16.7
Other	0.0	8.3
Age at first hospitalization		
M	17.6	21.2
SD	6.8	6.6
Range	(9–32)	(11–31)
Length of current hospitalization (mos.)		
M	39.6	22.8
SD	33.7	17.0
Range	(1–94)	(1–56)
Current neuroleptic dose (CPZ equivalents; mg/day)		
M	809.1	1312.5
SD	868.0	1132.6
Range	(0–2500)	(0–3750)
BPRS scores		
Thinking disturbance		
M	8.1	7.7
SD	4.9	3.2
Range	(3–17)	(3–14)
Anergia		
M	7.4	7.3
SD	3.8	3.7
Range	(3–13)	(3–12)
Total		
M	59.7	56.1
SD	14.7	14.2
Range	(32–81)	(31–72)

CPZ = chlorpromazine; BPRS = Brief Psychiatic Rating Scale

medication dose of the remaining 23 patients (16 males, seven females) who passed exclusion and performance criteria.

No significant group differences were noted on any of the descriptive measures. Sixteen of the 23 patients had chart diagnoses of schizophrenia or schizoaffective disorder at the time of testing (9/11 in the IE group; 7/12 in the NIE group); the remaining seven had other psychotic disorder diagnoses that included bipolar disorder ($n = 1$), major depression ($n = 1$), organic personality disorder ($n = 2$), and psychotic disorder not otherwise specified ($n = 3$).

Psychiatric diagnosis was determined by the staff psychiatrist on the patient's home unit. Nineteen of the 23 subjects were receiving neuroleptic medication at the time of testing (9/11 in the IE group; 10/12 in the NIE group). The total sample included 16 Caucasians, three African Americans, two Asians and two Latinos.

Procedure

Subjects in the IE group received a pre-test in the form of two standard administrations of the 128 card version of the WCST prior to training (total possible = 256 cards). Subjects in the NIE group were not given the pre-test prior to training. Both groups then received training on the WCST, which was followed by immediate, 1-week, 2-week, and 4-week post-tests using the 128 card version of the WCST.

The training procedures for the WCST were specifically designed to embody the principles of errorless learning. To approximate these parameters, the WCST was broken down into its constituent components to create a hierarchy of to-be-learned skills (i.e., stimulus feature identification, matching, and shifting of set) believed to be necessary for successful performance. Each phase of training consisted of a series of trials that included self- and other-delivered cues, as well as modeling, explicit instruction, and response feedback to facilitate correct responding and reduce the possibility of errors. Because of the nature of the WCST (errors are embedded into the task), a perfect adaptation of errorless discrimination training was not possible. Hence, these training procedures should be viewed as an approximation of errorless learning.

Subjects were required to meet selected standards of mastery at each phase. Subjects who failed to meet these standards did not receive further training. As noted earlier, four subjects failed to pass training criteria (two from the IE group, two from the NIE group). Training was conducted by a doctoral level researcher (LW) for each patient under the supervision of the senior author. Training typically required 1–2 h, including breaks, depending on the rate of the subject's progress. A brief description of the training procedures used in each phase follows (see Appendix for additional details):

Phase I (*stimulus feature identification*). Initially, subjects were trained to correctly identify the stimulus features on WCST cards. The instructor modeled stimulus feature identification by stating aloud the category and its corresponding exemplar for a sample WCST card. Subjects were then presented a series of WCST stimulus cards and instructed to say aloud the stimulus features particular to each card. For example, subjects were instructed to say, "Number one, color green, shape triangle," when presented a card with those particular stimulus features. Stimulus feature identification continued for 20 consecutive correct responses or until a maximum number of 64 cards were presented.

Phase II (*card matching*). In this phase, subjects were trained to match WCST stimulus cards according to category, mastering matching of one category before progressing on to the next. As in the previous phase, subjects were instructed to say aloud the category and corresponding exemplar for the match they were making. For example, "Color, green with green." Card matching continued until the subject correctly matched 20 consecutive WCST cards for each category (i.e., number, color, shape) or until a maximum number of 64 cards had been presented for any one category.

Phase III (*single shift execution*). Subjects were trained to make a single category shift through a series of training steps in which instructor prompts were successively faded. In the initial steps, the instructor provided explicit instruction about when to shift to a different matching category. These instructions and key indicators were successively faded over subsequent training steps until the subject was able to shift to a different matching category in response to only the instructor's verbal prompt, "Incorrect." All shifts of matching category were considered correct regardless of which of the other two categories the subject selected. Criterion for mastery included two correct single shifts of set or until 128 cards had been presented.

Phase IV (*double shift execution*). The same procedures were employed in phase IV as described in the "Single Shift Execution" phase, except that when the subject switched to a new category it was always considered incorrect the first time, thus requiring a second category shift. Criterion for mastery was set at two correct double shifts of set or until 256 cards had been presented.

Results

A series of analyses was conducted to address three questions: (a) was training effective; (b) were the effects of training durable; and (c) what effect, if any, did previously committed errors have on performance during and after training? The outcome measures of interest included number of categories achieved, number of perseverative errors, and percent conceptual level responses [i.e., (correct responses in runs of three or more divided by the total number of cards administered) × 100]. Card sorting errors committed during training were also examined. The means and standard deviations of pre- and post-training performance for the two groups are shown in Table 2.

Table 2
Means and Standard Deviations for the Two Comparison Groups on Selected Outcome Measures

	Pre-test		Immediate post-test		1 week follow-up		2 week follow-up		4 week follow-up	
Categories achieved										
IE	3.2	(2.1)	4.6	(1.8)	4.3	(2.5)	4.6	(2.1)	4.6	(2.5)
NIE			5.3	(1.3)	5.0	(1.6)	5.2	(1.3)	4.9	(1.6)
Perseverative errors										
IE	38.8	(26.4)	17.2	(13.5)	22.9	(28.7)	19.4	(24.9)	23.2	(29.2)
NIE			15.3	(14.8)	12.7	(11.5)	13.0	(9.9)	15.5	(13.9)
Percent conceptual level responses										
IE	41.5	(26.2)	62.4	(20.4)	61.9	(30.3)	64.5	(22.5)	60.0	(30.0)
NIE			67.3	(19.9)	72.0	(19.9)	72.5	(14.5)	66.2	(24.0)

IE = Initial Error group; NIE = No Initial Error group.

Effectiveness of training

The effectiveness of training was determined by conducting *t*-tests of pre–post differences for the IE group, since this was the only group that received a pre-test. These analyses revealed significant improvement in number of categories achieved (paired $t = -2.30$, $df = 10$, $p < .044$), number of perseverative errors (paired $t = 2.88$, $df = 10$, $p < .016$), and percent conceptual level responses (paired $t = -2.86$, $df = 10$, $p < .017$).

Durability of training

To assess the durability of the training effect, we conducted a 2 (groups: IE and NIE) ×4 (time: immediate, 1-week, 2-week, and 4-week post-test) repeated measures ANOVA. The results revealed no significant effect of time (i.e., no significant decline in performance) on any of the outcome measures over the four week follow-up period. These results are illustrated in Figure 1.

In addition, we conducted a 2 (diagnosis) ×2 (group) ×4 (time) repeated measures ANOVA to examine the additional effect of diagnosis (schizophrenia and schizoaffective disorder vs other psychotic disorder) on durability of WCST performance. There was no significant main effect of diagnosis, and the diagnosis × time interaction was not significant for any of the outcome measures. Hence, the schizophrenia/schizoaffective disorder diagnosed patients were not significantly different from patients with other psychotic disorder diagnoses.

Effects of error history

For the effects of error history on post-training performance, we reexamined the results of the 2 (groups) ×4 (time) repeated measures ANOVA for group and interaction effects. These results yielded no significant group or interaction effect on any of the outcome measures. In addition, we conducted a trend analysis to examine the slopes of the two groups over time. These analyses also failed to show any significant slope differences between groups on any of the outcome measures.

We evaluated the possible effects of error history (i.e., pre-training administration of the WCST) on training efficiency by comparing the number of errors committed by the two groups during training. Very few patients in either group made mistakes during phases I (stimulus feature identification) or II (matching); the majority of training mistakes were committed during phases III and IV (single and double shift execution). Nonparametric analyses (Mann–Whitney *U*) were conducted because of the skewed distribution of error scores. The results of this analysis failed to show any significant differences between the IE and NIE groups in the number of errors committed during training.

Discussion

The findings from the present investigation offer some support for using training procedures based on errorless learning principles to remediate WCST deficits in chronic psychotic inpatients. These training procedures which minimized the occurrence of errors committed during training were specifically applied with the prospect of yielding durable

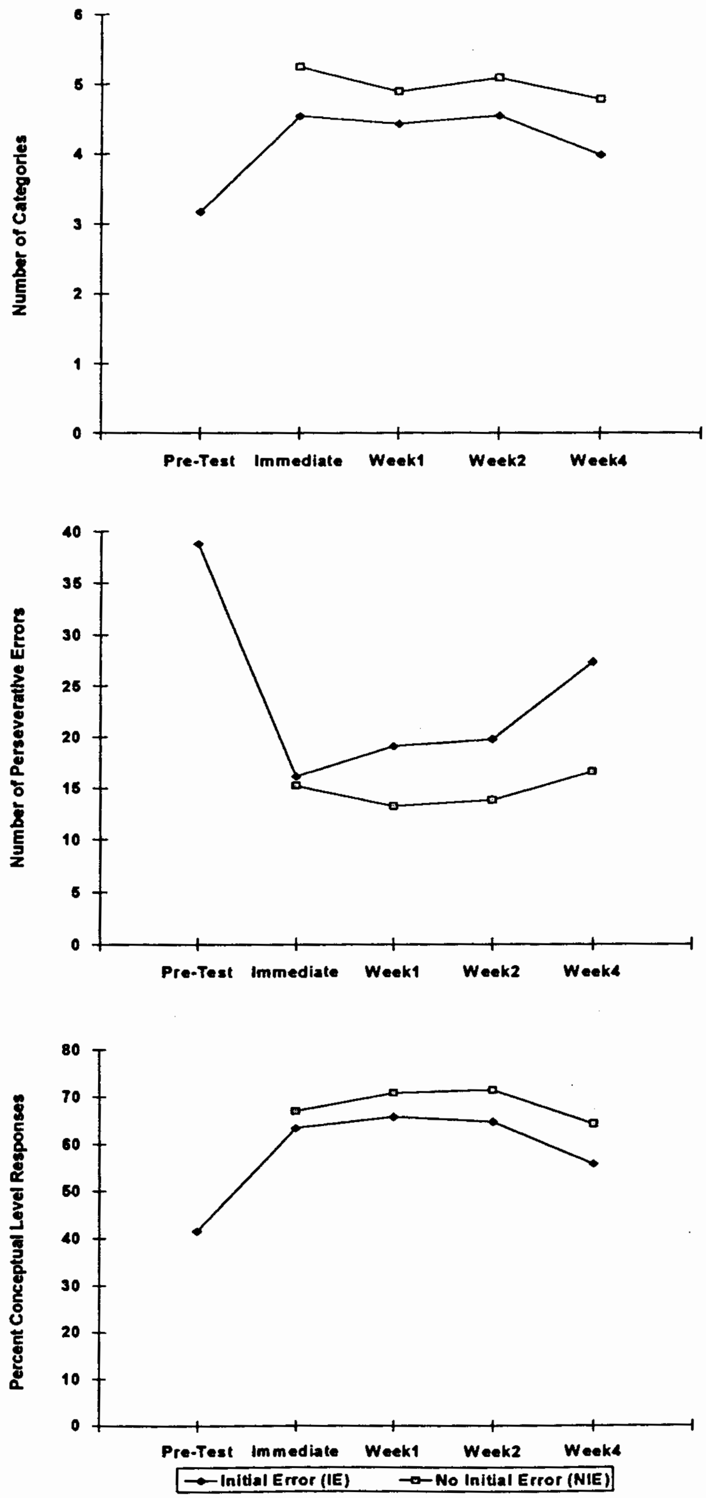

Figure 1. Pre- and post-training performance scores on the WCST for the initial and no initial error groups.

gains in performance. Our results showed that for those patients who successfully completed training, significant improvements were noted in categories achieved, perseverative errors committed, and percent conceptual level responses attained, and no appreciable decline was noted up to 1 month later.

To determine whether the gains from the training procedures were of a clinically meaningful magnitude, we compared the values of the combined patient groups (IE + NIE) with those of normitive data from adults of similar education (Heaton, 1981). Although the values indicate clinically meaningful gains (e.g., number of categories achieved: patients =4.9 (1.6), normal adults =5.1 (1.4); number of perseverative errors: patients = 15.7 (13.6), normal adults = 17.4 (11.6)), the comparison does not really indicate "normalization" of performance because the normitive sample had obviously never been trained as our patient sample had. We would be remiss without pointing out that criteria for study participation excluded subjects who failed to demonstrate certain basic information processing skills (i.e., the ability to identify WCST stimulus features). In addition, a small number of patients ($n=4$) were dropped from the study during training because of their inability to pass performance criteria. Hence, this type of training may not be appropriate for certain patients, such as those with profound conceptual disorganization or severe cognitive impairment.

Previous studies using explicit instruction and contingent reinforcement have demonstrated that performance deficits on the WCST can be modified, but the durability of these gains is suspect (Bellack et al., 1990; Goldberg et al., 1987; Green et al., 1992). In addition, data from our laboratory with similar patients to those in the current study also indicate limited durability for explicit instruction and monetary reinforcement, with much of the gains in performance lost within 1 week (Green et al., in press). Consideration of the limitations associated with explicit verbal instruction and contingent monetary reinforcement suggests that it would be unlikely for performance gains to be maintained over a lengthy period of time for the following reasons: (a) the functional deficits in verbal memory that are well documented in schizophrenia (Paulsen et al., 1995; Saykin et al., 1991) may place significant limitations on skill acquisition and retention under training conditions that are primarily verbally mediated; (b) the type of schedule of reinforcement used (e.g., fixed ratio) typically yields rapid increases in the frequency of the target behavior that is then followed by a rapid decline when reinforcement is stopped.

We based our training procedures on errorless learning because of the latter's established effectiveness at yielding durable gains in performance with other patient populations who are limited by cognitive deficits. In the present study, training procedures were designed to maximize the likelihood of response accuracy and minimize the commission of training errors. In addition, training consisted of learning a series of hierarchically ordered skills selected on the basis of their suspected relevance to WCST performance. It should be recognized that our training procedures only mimic the traditional experimental model of errorless discrimination training in which procedures are based primarily on stimulus shaping. Instead, training procedures in the current study were primarily directed at shaping a series of desired responses. Hence, these training procedures are an approximate, but not a perfect adaptation of errorless discrimination training.

This difference between stimulus shaping and response shaping could account for a failure to find an effect of previously committed errors on training and post-training performance. The prediction of an effect of pre-exposure was based on a study by Touchette (1968) in which four out of six severely retarded boys who previously engaged in trial-and-error learning of a simple discrimination task showed difficulty in the acquisition or subsequent retention of the to-be-learned discrimination following errorless training. By comparison, none of the six severely mentally retarded boys who only received errorless training showed any problems in retention on the 35-day followup. The programmed instruction employed in the Touchette study included sequential presentation of a series of stimulus slides, each slide differing slightly in appearance. In this type of training the subject responds to each slide only once, and training proceeds forward in a step-wise fashion until the target stimulus is reached. In contrast, the training procedures employed in the present study included repetitive practice of specific target responses. Such methodological differences between stimulus shaping and response shaping may have affected the potential influence of pre-training errors.

In terms of our understanding of the nature of training effects, it is frequently assumed that remediation of performance deficits on a particular measure of cognitive functioning (e.g., WCST) is synonymous with remediation of the underlying cognitive deficit. It is important to emphasize that this is not necessarily true. The observed gains in performance reported in the present study may be specifically related to the test parameters of the WCST instead of changes in the relevant cognitive construct(s). In the case of the WCST, one means of assessing whether one of the underlying cognitive constructs (e.g., set shifting) has been modified by these training procedures would be to test for performance gains on other measures believed to assess the same construct but whose methods differ (e.g., Categories Test).

In conclusion, the results from this study point to the promise of innovative training methods for teaching new skills and abilities in the chronically mentally ill. Obviously, the efficacy of these training procedures needs to be replicated in larger, independent, and perhaps less chronic samples. However, based on these results, the application of "errorless" learning at modifying selected deficits and teaching new skills appears promising. Further, there appears to be no reason why similar adaptations of errorless learning procedures cannot be applied to the teaching of a broad range of skills and behaviors, ranging from elementary cognitive processes to more complex social behaviors.

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Appendix

Training Procedures for the WCST

Phase I (stimulus feature identification)

In this phase, subjects received instruction about how to correctly identify the stimulus features of the WCST cards. Following a brief introduction to the task, subjects were presented a single WCST card and asked, "What do you see on this card?". Subjects were provided prompts when stimulus features were omitted or misidentified.

At this point subjects were introduced to two key rules (identification and matching) that would be used to guide later training responses. Subjects were presented a set of identification rule cards (three 4 × 6 inch laminated nonlined index cards, each containing the name of an identification rule (e.g., color) printed in black bold-face type) one at a time and asked to practice identifying WCST cards by using a particular identification rule. For example, "Using the color rule you could identify this card by the color of the figures on the card. What is the *color* of the figures on this card? (Subject responds correctly)." Good. Always say, "Color ———." Subjects were prompted with a standard correction cue after each incorrectly identified category. Following successful identification of individual stimulus features using each of the identification rule cards, the instructor then placed all three identification rule cards on the table and requested subjects to attempt to identify the WCST cards using all three rules at the same time. The instructor modeled these procedures by saying each category and its corresponding exemplar (e.g., "For this card we could identify it by saying, 'Number two, color green, shape triangle.'"). Subjects were then presented a series of WCST cards one at a time and instructed to do the same. Stimulus feature identification continued for 20 consecutive correct responses or until a maximum limit of 64 cards were presented. If the subject failed to correctly identify 20 consecutive cards within the maximum limit, no further training was attempted and the subjects' participation in the study ended.

Phase II (card matching)

In this phase, subjects were trained to match WCST cards according to each of the three sorting categories. To gain a sense of the subjects' ability to understand the concept of matching, subjects were initially asked, "What does it mean to match something?" If the subject was unable to provide a correct definition, he or she was presented two small pieces of colored paper (one yellow and one blue), and asked to place a third piece of paper (blue) on top of the one it matched. If the subject was unable to match the colored pieces of paper correctly, further training was discontinued. Next, four WCST key cards were placed in a row before the subject (same as in the traditional administration of the WCST), and the subject was asked to identify the stimulus features of each card as performed in Phase I. The instructor then said, "Remember how you identified these cards? You can match them the same way. You can match them for number, you can match them for color, or you can match them for shape." For example, "Number three with three." "Let's match some cards using the Number Matching rule." The matching rule card for number was placed above the row of WCST key cards. The matching rule cards were constructed similarly to the identification rule cards except that in addition to the category name, the four exemplars specific to that category appeared below the category name (e.g., the matching rule card for color included four patches of color (red, yellow, blue and green) below the category name). The instructor then presented a single WCST stimulus card and said, "Let's match some cards using the Number Matching Rule. We are going to take this card and match it with the one above that has the same number of figures on it. Tell me out loud how you are matching, then place the card directly under the card it matches. For example, we're matching by number so I would say, 'Number two with two.'" As each WCST stimulus card was handed to the subject, the instructor said, "Match for number." Matching continued for 20 consecutive correct matches or until a maximum of 64 cards had been used. Subjects were corrected if they made errors in card placement or in stating the correct match aloud. Subjects who failed to make 20 consecutive matches (i.e., correctly stating the match and correct card placement) did not receive further training. If the subject successfully met the mastery criterion for matching by number, training continued in a similar manner for color and shape.

Phase III (single shift execution)

This phase began by telling subjects that they were going to play a guessing game. The instructor stated, "I will think of a matching rule, but I won't tell you what the rule is. You will have to guess. You tell me the rule you're guessing, then match the card using that rule. For example say, 'I'm matching for color. Green goes with green.'" As in phase II, the four key cards were laid out in a row before the subject. However, for this phase all three matching rule cards were also laid out above the key cards to help the subject remember the possible sorting categories. The instructor continued, "I will say, '**Correct**'" (vocal emphasis), "if your match is right. I will say, '**Incorrect**,' if your match is wrong. So, if you hear, '**Correct**,' *stay* with the same rule because the one you chose is right. If you hear, '**Incorrect**,' *switch* to one of the other two rules because the one you chose is wrong. So what do you do if I say, '**Correct**?'" (subject response). "What do you do if I say, '**Incorrect**?'" (subject response). Queries were repeated and the correct response provided until the subject provided the desired response, i.e., correct = stay; incorrect = switch. The instructor then explained, "Every once in a while, I am going to switch to a new rule. So, even though the rule may have been correct before, it may not be later. When you hear me say, '**Incorrect**,' at any time, shift to another rule."

Subjects were then asked to begin sorting cards one at a time, stating which stimulus features they were using to make the match (as performed in phase II). Regardless of which category the subject selected for the initial match, the instructor said, "**Correct**." Card sorting continued until the subject made 10 correct matches in a row using the same matching rule (e.g., color). Then, on the 11th card the instructor said, "**Incorrect**." The instructor turned over the matching rule that had been used, and said, '(e.g., color) is no longer the correct matching rule because I've decided to switch to a new rule. You should change the rule on the next card." On the next subsequent card sort, if the subject changed to either of the other two categories, the instructor said, "**Correct**," and the subject was credited with a correct shift. Sorting continued as before until the subject made 10 in a row correct according to the new matching rule. Instruction procedures were gradually faded over four shifts of set. For the first two, instructions were explicit, that is the instructor told the subject that the matching rule had changed. In addition, when the instructor said, "**Incorrect**," it was delivered with vocal emphasis. For the third shift, explicit instructions were dropped and only vocal emphasis was used when saying, "**Incorrect**," and for the fourth shift, vocal emphasis was dropped. The same correction procedures used in phase II were used in phase III for each incorrect verbalization or card placement. Training continued until the subject achieved four correct shifts of set or a maximum of 256 cards were used.

Phase IV (double shift execution)

The same procedures were employed as used at the end of the "Single Shift Execution" phase, except that when the subject switched to a new category it was always considered incorrect for the first shift, thus requiring a second category shift. The corresponding matching rule card was turned over each time the subject made a new selection, so that only one sorting category remained in view of the subject by the time of the second shift of category set. As in phases II and III, each subject's incorrect verbalization or card placement received a standard corrective response from the instructor. Training continued until the subject achieved two correct double shifts of set or a maximum of 128 cards were used. Successful completion of Phase IV concluded training.