Effects of Contextual Processing on Visual Conditional Associative Learning in Schizophrenia

James M. Gold, Joel A. Bish, Virginia N. Iannone, Mary P. Hobart, Caleb A. Queern, and Robert W. Buchanan

**Background:** We adapted visual conditional associative learning paradigms to assess the contextual processing deficit model of schizophrenic cognitive impairment proposed by J.D. Cohen and D. Servan-Schreiber in 1992. In this task subjects learn the associations between four sets of stimuli through the use of feedback. We administered two experimental conditional associative learning conditions: in one, the eight stimuli used to make four pairs were all different; in the other, the pairs were made from different combinations of four identical stimuli, requiring the use of contextual information to mediate correct performance. Two additional associative learning tasks were administered where subjects generated the stimulus pairings or observed the experimenter form the pairs, eliminating the need to learn from feedback.

**Methods:** We tested 37 patients with schizophrenia and 20 healthy control subjects in each conditional associative learning task condition.

**Results:** Patients demonstrated significant impairments on all four conditional associative learning tasks. The demand to process contextual information did not differentially impact patient performance. Patients were better able to learn associations if they generated or observed the pairings rather than utilized feedback to guide learning.

**Conclusions:** Patients with schizophrenia demonstrate pronounced deficits in the ability to utilize feedback to guide learning. We found no evidence of an additional deficit in processing of contextual information. Biol Psychiatry 2000;48:406–414 © 2000 Society of Biological Psychiatry

**Key Words:** Schizophrenia, conditional associative learning, memory, context

**Introduction**

This study was designed to explore the context processing deficit model of cognitive dysfunction in schizophrenia proposed by Cohen, Servan-Schreiber, and colleagues (Braver et al 1999; Cohen et al 1999; Cohen and Servan-Schreiber 1992; Servan-Schreiber et al 1996). In brief, their theory suggests that patients with schizophrenia have a specific deficit in the “representation and maintenance of context information needed to select task-appropriate action” (Cohen et al 1999, 120). Further, they have proposed that this single mechanism, operating under different task conditions, may account for deficits on a variety of tasks that require selective attention, active memory, or inhibitory processing. The model suggests that patients are unable to use context representations as a form of “top down support for task-relevant processes” (Cohen et al 1999, 121). Without such support, patients often succumb to task-irrelevant distractions, noise, or failures to inhibit prepotent responses, such as naming the color ink of Stroop stimuli rather than reading the conflicting color names. Thus, the theory provides for an integrative, principled account for many different cognitive impairments in patients with schizophrenia through a single mechanism. Further, Cohen et al have suggested that abnormalities in prefrontal dopamine function may be the basis for this cognitive abnormality, directly tying the computational model to biology. The theory has been tested using tasks such as the Stroop and lexical disambiguation, and the Continuous Performance Test. Performance of these tasks involves significant response inhibition, and context representations are hypothesized to play a critical role in suppressing prepotent or experimentally induced inappropriate responses during the performance of these tasks. There is less empirical evidence that the theory accounts for performance deficits on tasks that manipulate the role of contextual information in the absence of prepotent response competition. Our study was designed to provide such a test.

We designed two conditional associative learning (CAL) paradigms to manipulate the role of contextual information in mediating performance success. Petrides has extensively studied CAL paradigms using a wide variety of methods and study populations including lesioned nonhuman primates, human focal lesion groups, and normal subjects studied with functional imaging. Results from all three research approaches have consis-
tently suggested that CAL is mediated by the posterior dorsolateral prefrontal cortex, and that successful task performance can often be achieved despite extensive medial temporal lobe removals. Material-specific CAL impairments have sometimes been observed following extensive unilateral hippocampal removals, suggesting that medial temporal structures may play a role in stimulus encoding but do not compromise the more general cognitive processes that are involved in the task. (Petrides 1982, 1985a, 1985b, 1990, 1997; Petrides et al. 1993). In monkeys, CAL deficits result from lesions of area 8 and rostral area 6, with little impact associated with lesions in areas 46 and 9, suggesting a high degree of cognitive-anatomic specificity. Given the functional anatomy implicated in CAL, it is not surprising that patients with schizophrenia have demonstrated deficits on this task (Kemali et al. 1987; Rushe et al. 1999). Our interest in using the task was not in demonstrating impaired performance in patients with schizophrenia: impaired performance was expected. Instead, we hoped to demonstrate a particular pattern of impairment.

In brief, in CAL tasks subjects must learn the associations between a set of stimuli and a set of responses. These fixed associations are typically acquired through a process of trial and error learning. For example, in a study by Petrides (1985b) subjects had to learn the associations between six different colored caps and six different abstract designs. The experimenter would initiate a trial by placing one of the color caps ahead of the others displayed on the table, and the subject’s task was to select one of the six designs presented together on a card that was paired with that specific color; the examiner informed subjects if their choice was correct or not. If incorrect, subjects continued response selections until the correct response was chosen. Thus, to successfully master the task over the course of learning trials, subjects must be able to discriminate between past correct and incorrect responses and use this information to guide response selection. The fact that each of the designs is correct for a specific stimulus heightens the role of interference effects (for a discussion, see Levine et al. 1997).

The precise cognitive process that is responsible for impaired CAL performance is somewhat less clear than the associated anatomy. Given the typical trial-and-error administration format, two different possibilities arise. First, subjects could have difficulty utilizing feedback to guide learning. Second, subjects could have a more basic difficulty in selecting between previously rewarded responses. Petrides (1997) adapted the CAL procedure to address the possibility that impairment resulted from failures in strategic processes that might be involved in trial-and-error learning. In this adaptation, subjects were first shown the correct associations between a series of hand postures and a series of color chips. In the testing phase, errors were immediately corrected, and the subject copied the correct response to strengthen the association. Thus, this paradigm eliminated much of the interference that occurs in the original trial-and-error learning format; however, patients with frontal lesions continued to demonstrate impairments (as did, to a lesser extent, patients with large left hippocampal removals). From these data Petrides argued that the CAL impairment “is a specific problem in learning to select, from a set of competing responses, the appropriate ones for the various stimuli” (1997, 995). Data suggesting that patients with frontal lesions benefit from modeling have been reported by Levine et al. (1997). The design of this later study, however, precludes a direct comparison to the Petrides results.

In CAL tasks the associations between stimuli and responses have a simple straightforward form (see Figure 1, unique task, which uses numbers as stimuli for ease of communication; in the experiment, shape stimuli were used). For example, if the experimenter’s stimuli were the numbers 1–4 and the subjects’ response set included the numbers 5–8, the correct association could be stated as follows: if presented with 1, then select 5; if presented with 2, then select 6; and so on. We devised a second CAL condition to increase the demand to process contextual information: the stimulus set and the response set included two identical sets of four shapes. The stimulus set items were not paired with their identical match in the response set (see Figure 1, crossed task). For ease of communication, we shall refer to the stimuli as A–D. In this condition, the association takes on a more complex form: if presented with A in the stimulus set, then select C in the response set. This A–C pairing is later followed by the item pairing C from the stimulus set with D from the response set. Unlike the unique CAL condition, the association between the identities of the two objects is not sufficient to mediate correct learning in the crossed condition. The subject must process additional information concerning which set the

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<tr>
<th>UNIQUE Task</th>
<th>CROSSSED Task</th>
</tr>
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<tbody>
<tr>
<td><strong>Stimulus</strong></td>
<td><strong>Response</strong></td>
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<tr>
<td>1 → 5</td>
<td>A → C</td>
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<td>2 → 6</td>
<td>B → A</td>
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<td>3 → 7</td>
<td>C → D</td>
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<td>4 → 8</td>
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Figure 1. Description of the conditional associative learning tasks.
item was drawn from (the stimulus or response set) on that trial to mediate correct performance. This additional information appears to fit Servan-Schreiber and colleagues’ (1996) definition of context information: “information that has to be held actively in mind in such a form that it can be used to mediate an appropriate behavioral response” (1105). Without the ability to represent which set the items are drawn from in the crossed CAL condition, subjects should demonstrate severely limited ability to learn correct pairings across trials.

If the above experimental manipulation does indeed increase the demand to process contextual information, then the Cohen and Servan-Shreiber model leads to a straightforward prediction of greater impairment in patients in the context, or crossed, condition. Such a result, however, might simply reflect differences in difficulty level across tasks. That is, we would expect that the demand to process additional contextual information would negatively impact the performance of control subjects as well as patients. Thus, a generalized deficit would also lead to prediction of worse performance in the crossed condition simply on the basis of differences in difficulty level. The particular design of the paradigm offers one potential defense against this critique. Context processing deficits should lead to a specific error type in the crossed condition: correct associations between two items, which are offered for the wrong set. Recall the example from Figure 1 above: 1) if presented with A then select C; 2) if presented with C then select D. If subjects select A when presented with C, they demonstrate awareness of the A–C pairing, but fail to properly process the context. This error results from a context reversal. Thus, we would expect both a pattern of worse performance by patients in the crossed condition and a preponderance of context reversal errors if the context processing deficit model is correct.

Methods and Materials

Subjects

PATIENTS. A total of 37 patients with a DSM-III-R diagnosis of schizophrenia participated in the study. Diagnosis was determined using a best-estimate approach, combining information from medical records, collateral informants when available, and the results of a structured interview. The patients were all clinically stable outpatients at the time of testing, as determined by their treating clinician. Subjects received the following subtype diagnosis: undifferentiated = 17, paranoid = 13, schizoaffective disorder = 4, catatonic = 2, disorganized = 1. All patients were tested while receiving clinically determined medication regimens. The majority of subjects (28/37) were taking one of the new-generation antipsychotics including clozapine alone (n = 8) or in conjunction with an antidepressant (n = 4) or a beta blocker (n = 3), olanzapine alone (n = 9) or in conjunction with a beta blocker (n = 1), risperidone alone (n = 1) or in conjunction with an anticholinergic (n = 2). Nine subjects were receiving conventional antipsychotics, including fluphenazine with an anticholinergic (n = 5), haloperidol with an anticholinergic (n = 5), haloperidol with an anticholinergic (n = 2), perphenazine (n = 1), and thioridizine (n = 1).

CONTROL SUBJECTS. A total of 20 healthy control subjects participated in the study. These subjects were recruited by newspaper advertisements and were extensively screened for the presence of Axis I and II disorders and for a family history of psychosis. In addition, subjects were screened for medical conditions that might impact cognitive performance including drug use. All control subjects were free of any significant personal psychiatric and medical history. All control subjects were free of any history of severe mental illness in first-degree relatives. After explanation of study procedures, all subjects provided written informed consent. Patients had to demonstrate adequate understanding of study demands, study-associated risks, and means of withdrawing from study participation in response to structured probe questions before signing consent documents. Healthy volunteers were compensated for study participation.

TASK CONDITIONS. Subjects first performed two training tasks that were intended to help establish a mental set that associations could be made between shapes before the administration of the CAL paradigms. The self-generated association condition was always administered before the modeling condition.

Self-Generated Association Condition Subjects were given two sets of four different cardboard shapes and instructed to pair them together however they would like, “so you will remember them.” The examiner noted the four pairings. Memory was tested by presenting one item at a time and requesting the subject to select the item they had paired with that specific item. Errors were corrected immediately. Correct pairing of each of the four shapes constituted a single trial. A total of four trials were administered, yielding a maximum total possible correct score of 16.

Modeling Condition In the modeling condition, subjects watched as the examiner made the four pairings (from a different set of shapes than was used in the self-generated condition), one at a time, and were instructed to watch carefully so that they would be able to remember the pairs. This was followed by four test trials, where one item was presented at a time, and subjects were asked to select the shape that had been paired with it by the examiner. Correct pairing of each of the four stimuli constituted a single trial. All errors were immediately corrected. The maximum total possible correct score was 16. This condition very closely resembles the procedure used by Petrides (1997). The stimulus materials used in the two training tasks were counterbalanced across subjects.

The two training conditions were designed as a kind of warm-up for subjects, to demonstrate the general idea that shapes could be associated with one another. Although initially designed
as training tasks, the sharp contrast in performance between these conditions and the CAL conditions described below provides some potential insight into the types of learning that patients with schizophrenia are able to master.

**CAL Unique Condition** In this condition, subjects were presented with a page displaying four shapes and were instructed that each shape on the page “goes with” one of four cardboard cutout shapes that the examiner placed on the table. The examiner would select one of the shapes and move it to the center of the table, and ask subjects to select one of their four shapes on the page that they thought went with the one selected by the examiner. Subjects were told that each stimulus shape goes with only one response shape throughout the test. Subjects were given feedback (right, wrong) for each selection they made, and testing for each stimulus was continued until subjects selected the correct response. After a correct response was made, the examiner moved that test stimulus back into the group of stimuli and put a new stimulus in the center of the table for testing. A trial was terminated when subjects had made correct selections for each of the four shapes. The spatial arrangement of the shapes on the pages varied from trial to trial. A maximum of 10 learning trials was administered. After two consecutive error-free trials, testing was terminated and subjects were credited with perfect responses for the number of remaining trials. The highest possible number of correct responses was 40.

**CAL Crossed Condition** This task was administered in the same fashion as the unique condition (using different shapes), with the same discontinue rules; however, the four stimuli presented in the binder and the four cardboard shapes were identical. Subjects were not informed that identical items were presented in the binder and the four cardboard shapes were with the same discontinue rules; however, the four stimuli were scored when a subject responded to a stimulus as if it were the original response (e.g., after learning the A–C pair, they later selected A when presented with C). Thus, this error type demonstrates the formation of an association between items but fails to account for the context of the pairing. In the event that an error could be classified as both a context reversal error and either a perseverative or within-trial error, only the context reversal code was counted, in light of the specific interest in this type of error.

**Results**

The groups differed on a number of demographic features. The control subjects were significantly younger than the patients (35.8; SD = 7.4 vs. 40.9, SD = 7.34, \( t = 2.512, p < .05 \)) and had more years of education (14.9; SD = 1.33 vs. 12.81, SD = 2.17, \( t = 3.914, p < .01 \)). In addition, control subjects scored higher than the patient group on the Wide Range Achievement Test 3 (WRAT3; Wilkinson 1993) reading subtest (101.1; SD = 7.5 vs. 91.53, SD = 13.34, \( t = 3.44, p < .001 \)). Although significantly different, it is important to note that the control group is not composed of “supernormals”; the control group scores very close to the normal population mean of 100 on the WRAT3. Analyses of covariance controlling for age, education, and WRAT3 effects did not alter the pattern of significant between-group effects reported below.

**The Impact of Context on Performance**

Figure 2 shows the total number of correct responses on each task for both groups. The prediction that patients would demonstrate more severe impairments on the crossed task than on the unique task was evaluated with a multivariate analysis of variance (MANOVA) that examined the main effects of group, task type, and the interaction of group by task on the total number of correct responses. The group by task interaction was tested and found nonsignificant \( [F(1,110) = 0.26, p = .61] \). After eliminating the interaction term from the model, we found significant main effects of group \( [F(1,111) = 38.26, p < .001] \) and of task \( [F(1,111) = 5.14, p < .05] \). Thus patients performed worse overall, and the tasks differed, with superior performance observed on the unique task. The lack of a significant interaction term suggests that the patient group was not unduly influenced by the context manipulation. An additional MANOVA was performed using the total number of errors as a performance index. The group by task interaction was tested and was nonsignificant \( [F(1,110) = 1.06, p = .31] \). After eliminating the interaction term from the model, we found a significant main effect of group \( [F(1,111) = 35.72, p < .0001] \), but the effect of task...
type was not significant \( F(1,111) = 1.08, p = .30 \). Thus, using this index of performance we found that normal subjects made fewer errors than patients, but there was no reliable impact of task type on number of errors.

To further explore the main effect of task noted above, we performed analyses within each group. Control subjects had significantly more correct responses on the unique task (33.45; SD = 5.43 vs. 28.75, SD = 7.34, \( t = 2.55, p < .05 \)) and made significantly more errors on the crossed task (17.25; SD = 10.27 vs. 9.85, SD = 8.77, \( t = 3.51, p < .01 \)). Thus, the additional load imposed by the need to process contextual information had a clear impact on control performance. Among patients, the effects of task type appeared to be less robust: the number of total correct responses was significantly higher on the unique task (22.32; SD = 10.52 vs. 19.32, SD = 8.11, \( t = 2.13, p < .05 \)), with no difference in number of errors as a function of task (32.13; SD = 22.23 vs. 33.00, SD = 14.58, \( t = .312, p = .76 \)). The fact that the context manipulation had more of a deleterious effect on normal control performance would appear to be directly counter to the predictions of a context processing deficit model of schizophrenia cognitive impairment.

**Error Analyses**

In addition to a reduction in the number of correct responses in the crossed condition, we predicted that patients would make an increased number of context reversal errors relative to normal control subjects (see Figure 3, which shows error types across tasks). We first compared groups on the total number of context reversal errors and found that patients made significantly more than control subjects (13.51; SD = 6.15 vs. 7.35, SD = 5.85, \( t = 3.67, p < .001 \)); however, patients also made significantly more of each type of error (simple incorrect, \( p < .001 \); within-trial error, \( p < .01 \); perseverative error, \( p < .01 \)), complicating interpretation of the total context reversal error score. To adjust for differences in total number of errors, we calculated context reversal errors as a proportion of total errors. This percentage did not differ across groups (40.6% [SD = 9.41%] and 36.24 [SD = 17.01%] for patients and control subjects, respectively; \( t = 1.05, p = .30 \)).

**Learning to Criterion**

Figure 4 shows plots of the cumulative percentage of subjects, by trial, who met the discontinue criteria of two consecutive error-free trials. On the unique task 13/37 (35%) of the patients and 16/20 (80%) of normal control subjects met the discontinue criteria; on the crossed task 7/37 (19%) of patients and 11/20 (55%) of normal control subjects met the discontinue criteria.
subjects met the discontinue criteria. The odds ratio for meeting the discontinue criteria on the unique task versus the crossed task was 2.32 ($z = 1.64, p = .11$) in patients and 3.27 ($z = -2.437, p = .01$) in control subjects. Using the generalized estimating equations method (Liang and Zeger 1985) for logistic regression for repeated measures, we compared the between-tasks odds ratios for discontinuation in patients versus control subjects and found that they were not significantly different [test for group $\times$ task interaction, $z(1) = -0.48, p = .6302$]. After we dropped the nonsignificant interaction term, the odds of meeting the discontinue criteria were estimated to be 2.64 times higher ($z = 2.58, p = .01$) for the unique task and were 6.17 times higher ($z = 3.52, p < .001$) in control subjects, as compared with patients. On a qualitative level, very few patients reach criteria after trial six in either condition, whereas the normal control group demonstrates more of a cumulative learning curve.

**Do Learning Deficits Result from an Inability to Use Feedback to Narrow Response Selection?**

Feedback in the CAL task should serve to reduce the number of possible response options for a subject. That is, if a response is incorrect (and the subject is able to remember the feedback), the total number of responses available to choose from for a given stimulus should decrease from 4 to 3. Similarly, feedback that a response was correct should serve to eliminate that particular item from consideration for future matches within that trial, as subjects were informed that each stimulus shape went with only one of the response shapes throughout the test. Failures to use feedback to eliminate errors in the unique task are reflected in the perseverative and within-trial errors category: in both instances, the subject had been informed that his or her response was incorrect or had already been used correctly for a different stimulus in the course of the same trial. Patients made significantly more of this type of error across all trials than did control subjects in the unique task (15.03; SD $= 5$ subjects in the unique task (15.32; SD $= 4.28$, $p = .001$) in control subjects. Using the generalized estimating equations method (Liang and Zeger 1985) for logistic regression for repeated measures, we compared the between-tasks odds ratios for discontinuation in patients versus control subjects and found that they were not significantly different [test for group $\times$ task interaction, $z(1) = -0.48, p = .6302$]. After we dropped the nonsignificant interaction term, the odds of meeting the discontinue criteria were estimated to be 2.64 times higher ($z = 2.58, p = .01$) for the unique task and were 6.17 times higher ($z = 3.52, p < .001$) in control subjects, as compared with patients. On a qualitative level, very few patients reach criteria after trial six in either condition, whereas the normal control group demonstrates more of a cumulative learning curve.

**Can Patients with Schizophrenia Form Novel Associations?**

An alternate explanation for the poor CAL performance among patients could involve a primary deficit in the ability to form associative connections between stimuli, independent of any difficulty utilizing feedback or selecting from among competing responses. This explanation appears somewhat less likely when the data from the two training conditions are examined. Figure 5 shows the total number of correct responses from the training and experimental CAL conditions. Control subjects scored significantly higher than patients in both training conditions ($t = 3.7, p < .001; t = 5.85, p < .0001$ for self-generated and modeling conditions, respectively). Inspection of the figure suggests that patient performance in the self-generated condition was clearly superior to the other three. This was confirmed by an analysis of variance examining the impact of encoding condition [$F(3,144) = 23.98$, $p < .0001$]. Bonferroni pairwise comparisons revealed that performance in the self-generated condition differed significantly from the other three conditions; modeling performance was significantly higher than either unique or crossed performance. This difference was dramatic: on trial two of the self-generated condition, after only one stimulus exposure, patients had a mean of 3.46 (SD $= 1.30$) correct responses, whereas performances in the unique and crossed conditions on trial two were 1.92 (SD $= 1.30$) and 1.81 (SD $= 1.22$), respectively. On trial two of the self-generated task 27/35 subjects were able to get all four pairs correct, whereas on the unique task only 6/37 were able to get 4/4 items correct, and on the crossed task only 2/37 had a perfect performance on trial two.

[Image 317x581 to 542x705]
Thus patients were able to form associations between shape stimuli, but the ability to do so was clearly affected by encoding condition.

Discussion

This study was originally designed to examine the context processing deficit model of schizophrenic cognitive impairment. The data directly addressing this issue appear to be inconsistent with predictions derived from this model. Although they fail to confirm those predictions, the training data combined with the CAL tasks provide some insights into the nature of learning impairment in schizophrenia that may have implications for rehabilitative approaches to the illness. These two issues are discussed here in turn.

Context Processing Deficits?

We failed to find evidence of a differential effect of the crossed CAL task versus the unique CAL task on the schizophrenia group, and further failed to find a disproportionate number of context reversal errors, our two primary predictions based on the context processing deficit model. One important question is whether the task manipulation and the specific predictions are reasonable extensions of the work of Cohen and Servan-Schreiber. We would argue that the additional processing demand imposed by the crossed CAL task versus the unique CAL task fits Cohen’s general definition of a context representation. That is, being able to maintain the representation of the two sets of items and the directionality of the associative pairings appears to involve “information which must be held actively in mind in order to mediate appropriate an appropriate behavioral response.” The second prediction, involving an increased proportion of context reversal errors, also appears to be consistent with the model. Such errors would result directly from an inability to process context information; however, such errors might only occur at a level of learning ability beyond that observed in most of the patients. That is, to make a context reversal error, subjects need to have formed an association. It appears that in CAL paradigms patients with schizophrenia have marked difficulty using feedback to guide associative learning. Thus, it could be argued that patients were performing at such a low level that it was not possible to observe the predicted pattern of errors. By analogy, Stroop interference effects can only be observed in subjects able to read. This argument in favor of the context model simultaneously raises a limit of the model: it implicitly posits a different mechanism as being responsible for the associative learning deficit. Thus, the defense of the model is achieved by suggesting that the model need not account for profound learning impairments, one of the critical deficits of the illness.

It could also be argued that CAL tasks inherently involve context processing, and that the deficits observed relative to control subjects on both tasks support the context processing deficit model. This formulation would suggest that the need to use feedback to guide the formation of arbitrary associations involves a form of contextual information processing. Further, the fact that all responses were correct for different specific stimuli may be seen as an additional demand to process context cues; however, even accepting this interpretation, it is hard to explain how a task manipulation that increased the demand for context processing, and reliably increased task difficulty in control subjects (as seen in the increase in errors and decrease in number of correct responses on the crossed task relative to the unique task), would fail to impact patients at least as much, if not more. We did not observe any such effect. Thus, even if overall CAL deficits may be attributed to difficulties in processing context, increasing the demand to process context should be expected to magnify impairment.

In considering these results in relationship to Cohen and Servan-Schrieber’s model, it appears that the concept of contextual processing is open to a number of interpretations. In our CAL paradigm, the context “representation” involved in the crossed task has specific informational value about the stimuli that are associated. That is, processing of the context information is needed to properly encode the items, and is an integral feature of the stimulus configuration. In Cohen and Servan-Schrieber’s model, context representations serve to guide cognitive processing or response selection. Thus, such representations function as a type of top-down control process and verge on the more familiar notion of “executive function.” Consistent with this notion of context, Cohen and Servan-Schrieber’s experimental work in patients has employed tasks where subjects have either a pre-experimental or an induced response set that conflicts with task demands. The “context” representation typically serves to bias subjects towards a less “dominant” response. Thus, it may be important to distinguish between context representations that are integral to accurate encoding and those that are needed to guide decision making and response selection. If this proposed distinction between types of context representation is accurate, it could be argued that the CAL crossed task did not test the context processing deficit model. That is, the type of context representation that was involved was inherent to the stimulus configuration rather than a separate, specific representation that might guide the processing of the shape pairings. If the concept of context specified by
the model is thus narrowed, the theory loses much of its explanatory power. At a minimum, it would be advantageous to adopt different terminology, as it appears the model concept and everyday uses of the term context have very different meanings and implications.

What Can Patients with Schizophrenia Learn?

Patients (and control subjects) demonstrated markedly better performance in the self-generated encoding and modeling conditions than in either CAL task. Such a result could be dismissed as simply reflecting differences in task difficulty, which is undoubtedly true; however, to do so may obscure an insight into what it is that makes a learning task more or less difficult. In both the self-generated and modeling conditions, the pairings are created or observed without the need to utilize error information. The superiority of performance in the self-generated encoding condition may be an example of the well-known generation effect whereby tasks that involve the subject in creating the to be remembered stimuli lead to enhanced recall relative to encoding conditions where the to be remembered items are provided to the subject (Slamecka and Graf 1978). But the superior performance in the modeling condition cannot be attributed to the generation effect in that there was no demand for self-initiated processing imposed. Thus, the relatively successful performance in the modeling condition raises the possibility that patients with schizophrenia have particular difficulties using feedback to guide learning. The ability to benefit from modeling and self-generation raises the possibility that the deficit in schizophrenia differs from the response selection deficit observed by Petrides in frontal lesion patients using a slightly different paradigm. This possibility is difficult to fully evaluate because Petrides did not administer both a trial-and-error learning and modeling version of the task to the same sample of frontal patients. In schizophrenia, the deficit appears to maximally involve the use of feedback information to hone performance.

Two aspects of the experimental design may confound the interpretation of performance in self-generated and modeling conditions versus the unique and crossed CAL conditions. The self-generated and modeling conditions were always administered before the unique and crossed conditions. Thus, it is possible that proactive interference may have played a role in suppressing performance on the unique and crossed tasks relative to the self-generated and modeling conditions. Further, the shapes used as stimuli were not fully counterbalanced across the four tasks. Thus it is possible, although unlikely, that the differences in performance level observed in the two training tasks versus the two CAL tasks may reflect uncontrolled stimulus effects; however, the contrasts between the self-generated and modeling conditions and those between the unique and crossed conditions were controlled by counterbalancing across subjects.

These data are consistent with recent approaches using errorless learning strategies with memory-impaired populations, including patients with schizophrenia (Baddeley and Wilson 1994; O’Carroll et al 1999). Such strategies are based on the notion that it is difficult for patients to suppress previous erroneous responses that may be retained in implicit memory; however, patients also made an increased number of within-trial errors, errors where a previously correct or rewarded stimulus was later selected as the pairing for a second item. Thus, the problem is not simply in eliminating errors. Patients have difficulty using external feedback, whether positive or negative, to bias later task selections away from inappropriate choices. That is, both positive and negative feedback appear to have less informational value for patients than for control subjects.

These data may have implications for the design of learning and training procedures for patients with schizophrenia. It appears that trial-and-error learning with feedback provided on performance adequacy might not be an optimal learning approach. Patients have difficulty using the feedback, including positive feedback to guide performance. Strategies that model correct performance or that facilitate successive approximations may be more effective methods of establishing new learning.

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