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Modification of Performance on the Span of Apprehension, a Putative Marker of Vulnerability to Schizophrenia

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The present study examined the effectiveness of 2 types of intervention (contingent monetary reinforcement and enhanced instruction) on span of apprehension performance. Forty chronic schizophrenia inpatients (26 men, 14 women) received a 3- and 12-letter array version of the span of apprehension task 4 times: baseline, intervention, immediate posttest, and 1-week follow-up. All patients were randomly assigned to 1 of 4 groups that differed according to method of intervention: repeat administration, monetary reinforcement only, instruction only, and monetary reinforcement plus instruction. The combination of monetary reinforcement plus instruction yielded significantly greater improvement in span accuracy than the other methods of intervention. These findings suggest that performance on this putative vulnerability indicator can be modified through certain interventions.

Recently, investigators have shown renewed interest in testing the feasibility of remediating schizophrenia patients' deficit performance on measures of cognitive functioning. Several studies have targeted performance on the Wisconsin Card Sorting Test (WCST; Milner, 1963), a widely used neuropsychological test that is thought to be sensitive to frontal lobe dysfunction. An early study using detailed step-by-step instruction reported that schizophrenia patients failed to show improvement beyond the highly structured training condition (Goldberg, Weinberger, Berman, Pliskin, & Podd, 1987); however, subsequent studies have shown that instruction and incentive (i.e., monetary reinforcement; Bellack, Mueser, Morrison, Tierney, & Podell, 1990; Green, Satz, Ganzell, & Vaclav, 1992) or incentive alone (Summerfeldt et al., 1991) can decrease the frequency of perseverative errors. However, it is less clear whether these gains can be maintained over time.

Although instruction and incentive may be helpful on a fairly complex cognitive exercise such as the WCST, it is not clear whether similar interventions would be effective on a measure of a more elementary cognitive process. One such measure of information processing that has been widely cited in the experimental psychopathology literature is the span of apprehension. One's span of apprehension refers to the number of items that can be attended to at one time (Woodworth, 1948). Traditionally, the span has been measured by having individuals identify selected target stimuli or entire stimulus arrays immediately following their presentation. One version that has been used in a number of studies with schizophrenia patients is the Estes and Taylor detection task (Estes & Taylor, 1966), a partial report, visual span of apprehension. This task requires identification of tachistoscopically presented alphabetic material of various array sizes. Under partial report procedures, individuals are required to identify one of two possible target letters from a multiletter array.

Some investigators have purported that this version of the span of apprehension may be a vulnerability indicator of schizophrenia. When tested during their psychotic episode, schizophrenia patients identified fewer target stimuli than normal controls on multiletter arrays (8 or more letters) of this task (Asarnow, Granholm, & Sherman, 1991; Nuechterlein et al., 1991). It is interesting that schizophrenia patients who are in remission also show deficits on this test when the letters are pre-

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sented using a wide visual angle (Asarnow & MacCrimmon, 1978, 1981; Nuechterlein et al., 1992). Further support for the span as a vulnerability marker may be found in the performance of offspring of schizophrenia mothers. Asarnow, Steffy, MacCrimmon, and Cleghorn (1977) found that span deficits were present in foster children born from schizophrenia mothers, but not in comparison groups of foster and community children. However, other investigators have not replicated these findings in other samples of children "at risk" for schizophrenia (Harvey, Weintraub, & Neale, 1985). Some of the inconsistency in this literature may be due to differences in the perceptual characteristics of the array (Asarnow et al., 1991).

In the present study, we tested the extent to which span of apprehension performance is modifiable in a group of chronic schizophrenia inpatients.

Method

Participants

The present study included 40 inpatients (26 men, 14 women) at Camarillo State Hospital who met criteria for schizophrenia disorder according to the third revised edition of *Diagnostic and Statistical Manual of Mental Disorders* (*DSM–III–R*; American Psychiatric Association, 1987); diagnostic information was obtained from an expanded version of the Present State Examination (Wing, Cooper, & Sartorius, 1974), supplemented with items from the Structured Clinical Interview for *DSM–III–R* (Spitzer, Williams, Miriam, & First, 1990). Diagnostic interviews were conducted by trained interviewers who had previously met competency criteria (85% or greater agreement for symptom presence) with the Diagnosis and Psychopathology Unit of the Mental Health Clinical Research Center at University of California, Los Angeles (UCLA). Patients with visual acuity of less than 20/30, history of alcohol/substance dependence, previous identifiable neurological disorder, mental retardation, or who were over 55 years of age were excluded from the study. Mean age and education for the total sample were 35.2 (SD = 6.3) and 11.7 (SD = 2.0) years, respectively. The mean duration of illness was 16.7 (SD = 5.5) years. The total sample included 21 Caucasians, 9 African Americans, 4 Latinos, and 6 Asians.

Patients from the total sample were sequentially assigned to one of four groups (10 in each group), designated A, B, C, and D. The groups differed by the form of intervention received during the second of four serial administrations of the span. (The type of intervention that each group received is described in detail in the section titled *Intervention procedures.*) To obtain approximately equal numbers of men and women in each group, sequential assignment of patients was performed separately for men and women. Table 1 shows the mean age, education, duration of illness, length of present hospitalization, current neuroleptic dose, and Brief Psychiatric Rating Scale (BPRS; Lukoff, Nuechterlein, & Ventura, 1986) scores of thinking disturbance and withdrawal–retardation clusters for the four groups. All BPRSs were administered within 2 weeks following the time of initial testing, and the ratings included the period of initial testing. In Group A, 8 patients were taking anti-Parkinsonian medication at the time of testing; this was also the case with 9 patients in Group B, 8 patients in Group C, and 9 patients in Group D.

Procedure

All patients were administered the same computerized version of the span of apprehension over four different administrations: baseline, intervention, immediate posttest, and 1-week follow-up. The baseline, intervention, and immediate posttest administrations were performed consecutively during a single session. All patients received standard administration of the span of apprehension at baseline, immediate posttest, and 1-week follow-up.

Standard administration procedures. Version 1 of the UCLA Span of Apprehension computerized program (Asarnow & Nuechterlein, 1987) was run on an IBM-PC computer with a Taxan 720 color monitor. A series of practice trials were presented and followed by 64 individual test trials (half of the standard administration), consisting of 3- and 12-letter arrays. Each patient first received sixteen 3-letter arrays, followed by thirty-two 12-letter arrays and then sixteen 3-letter arrays. Patients were seated 1 m directly in front of the monitor, and an examiner read out loud a set of standardized instructions explaining the testing procedure. Patients were instructed to identify which of two target letters (*T* or *F*) appeared on the screen by pressing one of two buttons (marked *T* or *F*, respectively) on a control pad as quickly as possible. Each patient held the control pad in the palm of the nondominant hand and placed the index finger of the dominant hand equidistant between the two response buttons. The letter arrays were presented for a duration of 80 ms. The location of the target letters was randomly distributed among the 16 possible target locations.

Intervention procedures. During the intervention (second test administration), four forms of the test were given, one for each group (Groups A–D). Each patient in Group A received repeat standard administration. Each patient in Group B received monetary reinforcement only (2 cents for every correct response). The reward was given immediately following a correct response by dropping two pennies into a container placed to the patient's left. Patients in Group C received instruction only (standard plus enhanced instructions before the practice trials). The enhanced instructions were prompts designed to increase target letter accuracy and included the following set of oral instructions:

1. "Get ready to push the button. Remember, *T* is on the left, and *F* is on the right."
2. "Look at the screen."
3. "Open your eyes as wide as you can."
4. "Say *T* and *F*."
5. "Say which letter you saw immediately after it appears on the screen."

A briefer set of these instructions with 1.27-cm (0.5-in.) tall black letters printed on a 21.59 × 27.94 cm (8.5 × 11 in.) white sheet of paper was positioned upright and to the right of the monitor. The prompts were reread to the patient immediately prior to the experimental trials. Patients in Group D received both monetary reinforcement and enhanced instructions as described above. Patients in Groups C and D were requested to report the target letter aloud; however, correct responses were determined by the button press.

Results

Group Comparisons on Demographic and Clinical Measures

The groups did not differ in age, $F(3, 36) = 0.30$, illness duration, $F(3, 36) = 0.78$, length of current hospitalization, $F(3, 36) = 0.43$, or symptomatology as measured by BPRS subscale scores for thinking disturbance, $F(3, 36) = 0.17$ and withdrawal/retardation, $F(3, 36) = 0.48$. In addition, analyses conducted with the Kruskal–Wallis test indicated that the groups did not differ significantly in years of education, $\chi^2(3, N = 40) = 4.21$, and current neuroleptic dose, $\chi^2(3, N = 32) = 7.42$. Because of the difficulties in converting depot medication to daily chlorpromazine equivalents, patients receiving depot

Table 1
Group Means and Standard Deviations for Patient Characteristics

	Group							
	A		B		C		D	
Characteristic	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Age	36.0	5.4	34.1	7.2	34.4	6.3	36.3	6.5
Education	10.1	2.4	12.6	2.3	12.4	1.7	11.5	1.6
Illness duration (years)	17.3	3.9	14.5	7.4	16.6	6.7	18.3	3.8
Length of present hospitalization (months)	24.4	30.7	16.6	19.3	26.2	29.4	17.0	9.9
Current neuroleptic dose[a]	1,895.0	1,032.4	814.3	484.5	944.4	596.0	1,598.3	1,004.2
BPRS scores								
Thinking disturbance	11.4	4.6	11.6	3.7	10.6	4.0	11.9	4.4
Withdrawal/retardation	7.2	3.5	6.4	3.0	8.1	2.6	7.4	3.3

Note. Group A = repeat administration; Group B = monetary reinforcement only; Group C = instruction only; Group D = monetary reinforcement plus instruction; BPRS = Brief Psychiatric Rating Scale.
[a] Units expressed in chlorpromazine equivalents (milligrams/day).

medication were not included in the comparisons for neuroleptic dose.

Group Comparisons on the Span of Apprehension Task

Initially, a univariate analysis of variance (ANOVA) was conducted to check for group differences in target letter identification at baseline. Only percentage correct for the 12-letter array condition was included in the analyses because the 3-letter array showed a ceiling effect for accuracy. The four groups did not differ significantly from one another on percentage of accuracy ($p = .73$). However, the repeat administration group (Group A) showed the lowest baseline performance, and small nonsignificant differences were noted between the other groups. Because baseline performance might be related to later outcome, it was treated as a covariate.

The primary analysis was performed using a 2 × 2 × 3 repeated measures analysis of covariance (ANCOVA) with an arcsine transformation. There were two between-group variables (monetary reinforcement vs. no monetary reinforcement; instruction vs. no instruction) and one within-group factor (time: intervention, immediate posttest, and 1-week follow-up). Performance at baseline served as the covariate, and an arcsine transformation of the data was used because the distribution of scores was negatively skewed. A preliminary test indicated that the assumption of parallel regression lines for the between groups effects part of the model was tenable, $F(3, 31) = 1.51, p < .23$.

The primary analysis revealed a significant monetary Reinforcement × Instruction interaction, $F(1, 35) = 4.14, p < .05$. There was also a significant main effect of instruction, $F(1, 35) = 9.20, p < .005$, but no significant main effects for monetary reinforcement or time. In addition, the two-way interactions of Time × Monetary Reinforcement and Time × Instruction and the three-way interaction of Time × Monetary Reinforcement × Instruction were all nonsignificant. Figure 1 illustrates the mean level of performance (nontransformed scores) for each group at the four administrations (baseline, intervention, posttest, and 1-week follow-up).

To examine further the Monetary Reinforcement × Instruction interaction, we conducted a one-way ANCOVA comparing the mean percentage accuracy scores of the four groups; again, baseline performance served as the covariate. There was a significant effect of group, $F(3, 35) = 4.76, p < .007$, with Group D showing greater percentage of accuracy scores than Groups A ($p < .001$, $d = 1.17$), B ($p < .03$, $d = 0.60$), and C ($p < .007$, $d = 0.85$).

Discussion

The results indicated that contingent monetary reinforcement plus enhanced instruction (i.e., verbal and visual prompts) significantly improved span performance in a group of chronic schizophrenia patients and was superior to either intervention used alone or repeated practice. The training effect

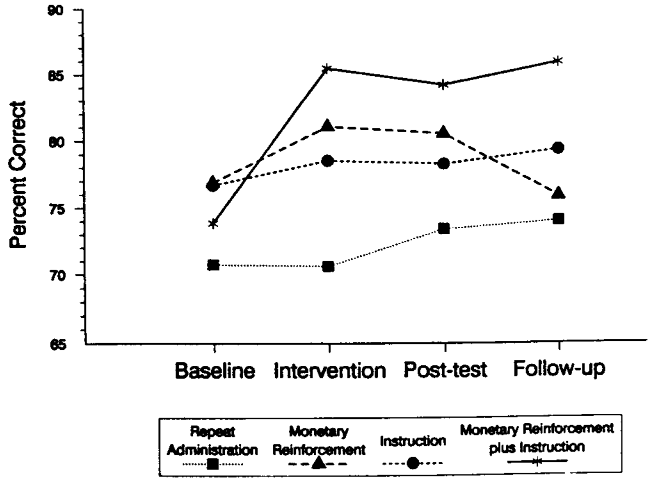

Figure 1. Mean percentage accuracy scores on the span of apprehension for groups receiving different interventions.

showed some degree of durability; the group that received both interventions showed no appreciable decline in performance up to 1 week after the intervention.

To understand how the intervention(s) affected performance, it may be helpful to examine the cognitive subprocesses thought to be involved in the span of apprehension task. In the present study, a type of span of apprehension task was used (Estes & Taylor, 1966) that was specifically designed to lessen the role of memory processes on span performance. The Estes and Taylor detection task requires that the individual identify which of two target letters appear within a multiletter array, and the individual knows prior to presentation the two target letters. This version of the span emphasizes cognitive processes other than memory, most likely serial scanning processes (Asarnow et al., 1991). Support for the relevance of serial scanning processes to span performance can be found in investigations showing that target letter accuracy decreases with increasing array size (Asarnow et al., 1977; Marder, Asarnow, & Van Putten, 1984; Neale, 1971; Neale, McIntyre, Fox, & Cromwell, 1969). In addition, both normal controls and schizophrenia patients have been shown to make more errors when the target letter appears in the lower two quadrants (Asarnow & Sherman, 1984; Neale, 1971), suggesting that both groups use a top to bottom (e.g., reading style) scanning approach.

Although both normal controls and schizophrenia patients perform more poorly on the span under larger multiletter array conditions than smaller ones, the performance of schizophrenia patients increasingly diverges from normal controls as the number of letters in the visual array increases (Asarnow & MacCrimmon, 1978, 1981, 1982; Asarnow et al., 1977; Neale, 1971; Neale et al. 1969). Furthermore, Asarnow and Sherman (1984) found that schizophrenia children differed from normal children only in their detection of target letters presented in the upper quadrants. Hence, the major determinant of these group differences appears to be related to impairments in the initiation, speed, or efficiency of serial scanning processes. Asarnow et al. (1991) proposed four hypotheses about which cognitive subprocesses might be dysfunctional in the serial scanning of schizophrenia individuals. These include: (a) impairment in one or more discrete computational systems (i.e., the engage, move, or disengage functions); (b) limitations in the amount of information that can be processed; (c) a generalized delay in the initiation of cognitive processes; and (d) impairment in the recruitment or allocation (or both) of sufficient information processing capacity.

How could the type of intervention used in the present study have affected these cognitive subprocesses? We could speculate that enhanced instruction and monetary reward affected span performance through somewhat different means (given the significant interaction). The enhanced instructions used in the present study may have increased the readiness of patients prior to stimulus presentation, thereby facilitating sensory efficiency. In this case, performance could be affected by an individual's heightened ability to first engage and subsequently react to the stimulus. Alternatively, contingent monetary reinforcement may have affected cognitive processing in a slightly different way by affecting motivation. Increasing incentive may have improved target letter identification by biasing allocation policy away from non-task-related processing toward the span of apprehension task.

The combination of instructive prompts plus monetary reinforcement yielded a statistically significant effect, but did it yield a meaningful change in performance? The group that received the combination of monetary reinforcement plus instructive prompts showed a 12% increase in target letter accuracy at intervention (a gain maintained over the two subsequent administrations). In contrast, relatively minimal gains in performance were noted in the groups that received instruction alone (2%) or monetary reinforcement alone (4%). Furthermore, the overall level of performance in the group that received both monetary reinforcement and instruction (85% target letter accuracy) approximates that typically observed in normal controls under standard administration procedures. Of course, we do not know what the performance of normal subjects would look like under these same experimental conditions. Nonetheless, the change in performance can be considered meaningful and not merely statistical.

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