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The Game of Bridge as an Exercise in Working Memory and Reasoning

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Fifty bridge players and 50 nonplayers, between the ages of 55 and 91, were given tests of working memory, reasoning, reaction time, and vocabulary. Data were analyzed using multivariate and univariate analyses of variance with age as a covariate. Results indicated that the players outperformed nonplayers in measures of working memory and reasoning, but not vocabulary and reaction time. Results were consistent with the hypothesis that bridge, which provides specific experience in working memory and reasoning, should enhance performance in tasks tapping these abilities and not enhance performance in unrelated abilities. Because the data were correlational, the rival hypothesis that bridge playing selects for individuals who perform better at working memory and reasoning tasks could not be rejected.

PREVIOUS studies have shown that the performance of older adults on tests of inductive reasoning can be improved through training programs (Baltes & Schaie, 1976; Blackburn, Papalia-Finlay, Foye, & Serlin, 1988; Bleiszner, Willis, & Baltes, 1981; Labouvie-Vief & Gonda, 1976; Schaie & Willis, 1986; Willis, Bleiszner, & Baltes, 1981). Moreover, two of these studies suggest that a period of practice is often more effective than specific strategy training. Labouvie-Vief and Gonda trained participants on one inductive reasoning task, letter series, and tested them on a transfer task, Raven's Progressive Matrices. They reported that improvement on both immediate and delayed transfer tasks was greater for the unspecific training group, which received only practice, than for the specific strategy group. Blackburn et al. gave their self-training group, in addition to practice, feedback on the correctness of responses and an opportunity to discuss strategies with other participants. Although improved performance on transfer tasks was seen for both specific strategy and self-trained groups, the effect of self-training was more durable over time. These studies suggest that practice on one task can improve performance on a related task.

Many life-style activities tap, to varying degrees, those same cognitive skills that are measured by tasks designed by psychologists. An example is the game of bridge. Conscientious bridge players attempt to retain in memory information regarding the bidding of each player and the cards that have been played. While holding this information in memory, they must attend to the current play. Throughout the game, there is the constant need to add new information to the memory store. Players must decide which items of the previously acquired information should be retained and which can be discarded as no longer useful. An experienced player will use information held in memory to make reasonable inferences concerning the cards held by his or her partner and opponents in order to determine the best strategy for winning the largest number of tricks. The player is continually forming mini-hypotheses and modifying them as new information is obtained. Each card played provides clues to the cards held by other players, information that is crucial in formulating the play of the hand. Thus the game of bridge is an activity requiring the exercise of both working memory and reasoning ability.

The question addressed by the present study is whether practice in cognitive skills gained from engaging in a complex activity such as the game of bridge, will transfer to performance in a task designed to measure that skill. We believe that bridge playing can enhance cognitive performance just as formal education and experience in scientific endeavors enhance performance on reasoning tasks. Specifically, we propose that because of the practice gained from playing bridge, (a) the performance of bridge players will be superior to the performance of nonplayers in tests of working memory and reasoning, those skills for which bridge provides specific experience, and (b) there will be no difference between groups for unrelated abilities, reaction time (RT), and vocabulary.

METHOD

Participants

Participants were selected from a larger sample of 300 men and women between the ages of 55 and 91, who had been recruited for a comprehensive study of activity-ability relationships. Of the 300 participants, 41 were recruited from duplicate and social bridge clubs, and the remaining 259 from general community sources (retirement communities, senior centers, churches, athletic organizations, adult education, and other community organizations). Participants were all living independently in the community or in retirement communities. They were screened for neuromuscular and central nervous system disorders, including history of a stroke or transient ischemic attacks, and for visual disorders sufficiently severe to interfere with performance. Each participant was paid $15.00.

The game of bridge can be played at different levels. For some, it is primarily a social outlet in which there is a running conversation during the game and little attempt to keep track of what cards have been played; for others, it is a challenging game requiring intense concentration. From the 127 bridge players in the sample, we selected a group of 11 men and 39 women who were judged to be relatively conscientious and skilled players. All played bridge at least once a week. Thirty-seven played duplicate, a more competitive form of bridge, and stated that they preferred duplicate to social bridge. Thirteen were not duplicate players, but indicated their preference for a more serious game of bridge by responding negatively to the following statement: "I enjoy bridge primarily because of the people I am with rather than because of the game itself." Thirty-five of the bridge players were drawn from bridge clubs, and 15 from general community sources. The oldest participant was 77. A group of 50 nonplayers, which included 18 men and 32 women, was selected at random from the 173 participants, under the age of 78, who did not play bridge.

Table 1. Means of Age, Health, Exercise, and Subjective Well-Being Variables for Bridge and No-Bridge Groups

	Bridge		No Bridge	
	M	*SD*	*M*	*SD*
Age	67.09	5.09	70.2	6.51
			67.08	**5.05**
Years of education	15.92	2.94	15.94	1.98
			15.66	**1.45**
Self-rated health	5.82	1.06	5.48	1.11
			5.68	**1.11**
Kilocalories/week	2466.86	1370.44	2483.50	1694.43
			2470.80	**1484.02**
Hours of strenuous exercise/week	2.52	3.00	1.93	2.32
			2.42	**2.98**
Life Satisfaction Index	32.74	4.27	31.18	5.63
			32.16	**4.95**
Feelings Scale	5.50	3.39	5.06	4.88
			6.12	**3.63**

Note. Means and *SDs* for matched sample are in **bold** print.

Procedure

The procedure is described fully in Clarkson-Smith and Hartley (1989).

Participants were asked to rate their health on a 7-point scale, with 7 indicating excellent health and 1 indicating poor health. Data were also obtained on average weekly expenditure of kilocalories from all activities requiring at least moderate exertion. This was included because in a previous study, Clarkson-Smith and Hartley (1989) had shown that the performance in reasoning, working memory, and RT of a group of exercisers, drawn from the same sample of 300 participants, was superior to the performance of a group of nonexercisers. Participants were also asked to complete two questionnaires assessing subjective well-being, the Life Satisfaction Index A (Neugarten, Havighurst, & Tobin, 1961) and the Feelings Scale of the Questionnaire for the Study of Modern Living (Bradburn & Caplovitz, 1965). The 20 items in the Life Satisfaction Index were scored according to a system suggested by Wood, Wylie, and Sheafor (1969). Responses indicating a high level of satisfaction received a score of 2, those indicating a low level of satisfaction were scored 0, and uncertain or uncommitted responses were scored 1. The Feelings Scale was scored in the standard manner with positive scores for positive feelings and negative scores for negative feelings. Means of age, health, exercise, and subjective well-being for the two groups are presented in Table 1.

Working memory tasks. — The first working memory task, letter sets, was a modification of a task introduced by Crawford and Stankov (1983). Two sets of two, three, or four letters were presented sequentially on a screen with a short interstimulus interval. One letter in each set was different; the others were the same (e.g., LFG and GLS). The task was to determine which letter was different in each set. The score was the number of correct responses, summed across sets, and weighted by the number of letters in each set for which a correct response had been given.

The second working memory task was Digit Span Backwards from the WAIS (Wechsler, 1955). To be comparable with scoring of the letter sets task, the score was the number of correct responses weighted by the number of digits in each set and summed across sets.

Reading Span was a task adapted from Daneman and Carpenter (1980), in which the participant read aloud a set of sentences and then was asked to recall the last word of each sentence. Set size ranged from two to six. The score was the number of correct responses weighted by the number of sentences in each set, and summed across sets.

Reasoning tasks. — The three reasoning tasks were, (a) 30 common-word verbal analogies, graded for difficulty (Clarkson-Smith, 1985), (b) 20 graded items selected from *Advanced Progressive Matrices, Sets I and II* (Raven, 1972, 1974), (c) and 15 letter series completion items (Horn, 1975).

RT tasks. — Simple, two-choice, and four-choice RT tasks were administered on an Apple Macintosh computer. Each stimulus was preceded by a tone followed by a variable interval ranging from .1 to 3 seconds. The value for each of the RT measures was the geometric mean for 30 correct responses. The geometric mean, rather than the arithmetic mean, was used in order to lessen the influence of outliers. This measure has been used by Scialfa and his colleagues (Scialfa & Kline, 1988; Scialfa, Kline, & Lyman, 1987). Three measures of RT were used in the analyses: (a) RT averaged across the three conditions, (b) standard deviation averaged across the three conditions, and (c) slope, the linear increase in RT as a function of the number of bits of information.

Vocabulary. — The vocabulary test from the Shipley-Hartford C. Q. Scale (Shipley & Burlingame, 1941) was presented on an Apple Macintosh computer.

RESULTS

Analyses of variance (ANOVAs) were performed on the variables listed in Table 1. Significant between-group differences resulted only for age, $F(1,98) = 7.07, p < .01$. Thus age was used as a covariate in analyses of performance variables.

As the large number of analyses to be performed increased the probability of a Type I error, multivariate analyses were carried out on each of the three classes of ability variables, working memory, reasoning, and RT. Univariate analyses of variance were performed only on those variables for which multivariate analyses were significant. Initial multivariate analyses were carried out with bridge group and gender as between-subjects variables and age as a covariate. The only gender main effect was for RT, with increased latency for females, $F(3,93) = 3.10$, $p < .05$. In subsequent analyses of reasoning, working memory, and vocabulary, data were collapsed across gender. As had been predicted, significant between-group differences resulted for reasoning and working memory, $F(3,95) = 2.72$, $p < .05$, $\text{Eta}^2 = .08$, and $F(3,95) = 5.13, p < .01$, $\text{Eta}^2 = .14$, respectively. Group differences for RT and vocabulary were not significant, $F(3,95) = 1.28$, and $F(1,97) = .41$, respectively. Regressions of reasoning and RT on age were significant, $F(3,95) = 3.61$, $p < .05$, $F(3,95) = 2.85$, $p < .05$, respectively. F values for multivariate analyses were based on Wilks' lambda.

As significant between-group differences resulted for multivariate analyses of working memory and reasoning, univariate analyses were performed to determine which individual tests accounted for the differences. Observed and adjusted means and F values for univariate analyses, which are presented in Table 2, show that there were significant between-group differences for two working memory tasks, letter sets and digit span backwards, and two reasoning tasks, matrices and letter series.

To strengthen the argument that group differences were a function of bridge playing, rather than of age or other potentially confounding variables, an additional set of analyses was performed using an alternate method of controlling for age. Each participant in the original bridge group was matched for age with one of the 138 participants in the no-bridge group. When more than one age match was possible, participants were also matched for education. As can be noted in Table 1, means of the two groups for all variables were very close. Multivariate analyses comparing this new matched sample of nonplayers with the original bridge group, produced results similar to those of the original analyses, $F(3,96) = 2.81, p < .05$, $\text{Eta}^2 = .08$, and $F(3,95) = 5.32$, $p < .01$, $\text{Eta}^2 = .14$, for reasoning and working memory, respectively. As in the original analysis, the difference between groups for RT and vocabulary was not significant. Results of univariate analyses followed a pattern identical to those of the original analyses.

To further investigate the relationship of age to performance, the bridge group and the matched no-bridge group were divided by age into three subgroups, young-old (55–62), middle-old (63–69), and old-old (70–77). Means and standard deviations for the three age groups are shown in Table 3. The general pattern was one of stability through the sixties, and a decline in the seventies. Interestingly, the performance of the middle-old group was superior to that of the young-old group for each of the working memory tasks. This explains the lack of a significant regression of working memory on age.

Table 2. Observed and Adjusted Means and F Values for Working Memory and Reasoning as a Function of Bridge

	Bridge		No Bridge		
	M	*SD*	*M*	*SD*	*F*
Working Memory					
Letter sets	48.26	15.28	38.20	15.07	
	47.84		**38.62**		8.60**
Reading span	14.38	9.1	13.36	7.03	
	13.96		**13.78**		0.01
Digit span	28.96	14.68	22.26	11.87	
	28.5		**22.72**		4.01*
Reasoning					
Analogies	23.38	3.65	22.52	4.43	
	22.52		**22.86**		0.05
Matrices	14.82	3.02	12.66	4.74	
	14.59		**12.89**		4.47*
Series	12.14	2.59	10.56	3.29	
	11.95		**10.75**		4.01*

Note. Means in **bold** print were adjusted for age. df = 1,97.
$^*p < .05$; $^{**}p < .01$.

We next investigated the possibility that advantages similar to those of bridge players might be seen for groups of individuals who participate in other activities. From the original sample, groups were formed of individuals frequently participating in the following activities: community organizations ($n = 62$), volunteer work ($n = 39$), writing ($n = 31$), financial management ($n = 46$), crossword puzzles ($n = 60$), remunerative employment ($n = 63$), and public speaking ($n = 64$). Analyses similar to those performed for the bridge players were performed separately for each type of activity. The only participants to show any superiority in working memory or reasoning performance over a randomly selected group of nonparticipants were those who engaged in public speaking. They were superior in one test of working memory, reading span, $F(1,123) = 5.55, p < .05$.

In previous studies of bridge players, Charness (1979, 1987) compared the performance of novice and expert bridge players. Although the focus of the present study was on the performance of bridge players vs nonplayers, we wished to see if our results would be consistent with these previous findings. Therefore, making the assumption that duplicate players are more skilled than social bridge players, we compared the performance of the 62 participants who reported that they played at least some duplicate, with the 65 participants who played only social bridge. MANOVAs were performed with age and education as covariates. Results were consistent with the studies of Charness in finding no performance advantage for the duplicate players.

One task used in the present study, digit span backward, had also been used by Charness (1987). The backward digit span score (when using the traditional method of scoring used by Charness) was $M = 5.2$, $SD = 1.5$ for the bridge players in the present study, and $M = 6.2$, $SD = 1.4$ for the Charness sample. The differences probably reflected the

Table 3. Performance Means and (*SDs*) for Bridge and Matched No Bridge Groups by Three Age Subgroups

	Young-Old		Middle-Old		Old-Old	
	Bridge	No Bridge	Bridge	No Bridge	Bridge	No Bridge
Task	(*n* = 10)	(*n* = 10)	(*n* = 25)	(*n* = 26)	(*n* = 15)	(*n* = 14)
Working Memory						
Letter sets	48.10	42.80	50.76	42.04	44.20	32.07
	(15.65)	(14.93)	(15.88)	(15.31)	(14.09)	(13.61)
Reading span	12.10	11.70	17.20	15.50	11.20	11.07
	(8.69)	(4.22)	(10.61)	(7.60)	(4.38)	(7.11)
Digit span	27.40	22.10	32.00	23.50	24.93	19.29
	(12.79)	(10.62)	(15.74)	(10.91)	(13.75)	(13.51)
Reasoning						
Analogies	24.20	24.10	24.28	23.19	21.33	19.14
	(2.74)	(2.42)	(3.14)	(3.53)	(4.29)	(4.43)
Matrices	15.20	15.00	15.48	13.31	13.47	11.07
	(1.62)	(2.94)	(2.33)	(4.22)	(4.26)	(4.48)
Series	12.30	11.70	12.24	10.96	11.87	9.43
	(1.89)	(2.58)	(2.30)	(3.13)	(3.46)	(2.77)
Response Time						
RT	1583.50	1574.10	1576.20	1625.69	1666.13	1781.86
	(158.46)	(160.87)	(177.62)	(182.37)	(202.96)	(202.06)
SD	522.40	492.25	473.82	510.22	541.03	622.59
	(170.10)	(157.62)	(108.04)	(139.72)	(157.78)	(173.55)
Slope	.246	.210	.205	.218	.231	.278
	(.084)	(.073)	(.063)	(.058)	(.064)	(.103)
Vocabulary	35.30	37.00	36.80	35.27	35.60	33.21
	2.87	2.49	2.71	3.09	3.83	4.54

differences in age ranges of the samples. The range in the Charness sample was 21 to 71, while the range in the present sample was 55 to 77.

DISCUSSION

The performance of bridge players was superior to the performance of nonplayers on two tests of working memory and two tests of reasoning. These results are consistent with the training studies reviewed earlier and with Denney's (1982) hypothesis that abilities which are used frequently as people age will decline at a slower rate.

Although training studies suggest that reasoning skills may transfer from one task to another, there is no evidence in the literature for transfer of working memory skills. Charness (1979) found that experts were able to remember more about bridge hands than novices. However, when given a free-recall task of cards, the performance of experts was superior to that of novices only when the cards were arranged according to suits. The advantage disappeared when the cards were randomly distributed. Charness (1987) also found that scores of combined forward and backward digit span did not correlate with skill in bridge. He (Charness, 1979, 1987) attributed the superiority of expert bridge players in retaining information about bridge hands not to increased short-term memory but rather to the superior encoding strategies of skilled players. He reasoned that, because the experts were better able to recognize patterns and relationships among the cards, they were able to encode the information in larger and more meaningful chunks. A similar conclusion was reached by Chase and Simon (1973) in their study of novice and expert chess players. Thus these studies suggest that working memory skills are task-specific.

Because of differences in the tasks used and in the composition of the sample, it is difficult to draw a comparison between the results of Charness and those of the present study. In his 1979 study, Charness used a free-recall task, and in the 1987 study, combined forward and backward digit span scores. We believe that the working memory tasks used in the present study, letter sets, reading span, and digit span backward, more closely simulate the type of processing required of bridge players. These tasks require not only the retention of information, but the ability to reorganize information while retaining it in memory.

According to the hypothesis of the present study, we would expect a difference in performance as a function of bridge only for the older participants. Actually, for the sample in the Charness study, which represented a wide range of ages, there was a nonsignificant positive correlation between digit span and bridge skill. It is possible that if the analysis had been restricted to the performance of people over the age of 55 the correlation might have reached significance.

A final difference is that we compared the performance of bridge players with nonplayers while Charness compared the performance of experts with novices. Our hypothesis is that age-related deterioration of cognitive abilities, such as working memory, is delayed when individuals participate in activities requiring use of these abilities. The emphasis is on experience rather than skill. We believe that the novice may derive as much working memory experience from the game of bridge as the expert. In fact, because of less skill in encoding, the working memory demands on the novice may be even greater. Also, there is no evidence that the experts in the Charness (1987) study had more experience than the novices; he reported that there was no significant relation between the level of skill and years of play. Thus, because of differences in the composition of our subject sample and in the selection of memory tasks, our findings of working memory differences between bridge players and nonplayers do not appear to be inconsistent with the failure of Charness to find differences in memory performance between novice and expert bridge players. Our finding of no difference in performance between duplicate and social bridge players, in an attempt to roughly approximate the Charness groups, is consistent with the findings of Charness, and suggests that it is experience rather than skill that is related to superior performance on related cognitive tasks.

The notion of task specificity has been studied by Daneman and her colleagues (Daneman & Green, 1986; Daneman & Tardiff, 1987) in relation to reading skill. They suggest that performance on working memory tasks depends on the specific processing demands of the task rather than on a general storage capacity. Daneman and Tardiff found that working memory tasks tapping verbal processing correlated more highly with reading comprehension than working memory tasks tapping mathematical processing. Working memory tasks involving spatial processing did not correlate with reading comprehension at all. These results were interpreted as supporting a language-specific processor. Our results are consistent with this notion and suggest that processing skills required for bridge differ from skills involved in verbal comprehension. The only group, other than bridge players, to show any superiority of performance were those individuals who engaged in public speaking. They were superior only in reading span, the one memory task measuring verbal memory, a skill used in public speaking. In contrast, the superiority of bridge players was seen in nonverbal tasks of memory and reasoning, skills used in playing bridge.

Although the results suggest that the superior performance of the bridge group may have resulted from the experience of playing bridge, we must consider an alternate possibility, that those who chose to play bridge were initially superior in working memory and reasoning. It is true that bridge is a challenging game that should be appealing to more competent individuals. Thus it may be that those individuals with superior reasoning and working memory abilities are drawn to the game to the exclusion of those who are less competent. It is also possible that less competent individuals who start playing bridge may discontinue playing because they are not successful. However, for several reasons we believe that this was not the case for the sample in our study. This hypothesis would suggest that the more competent individuals would choose duplicate, the more demanding form of the game. Yet our results show no performance differences between social bridge and duplicate players. Furthermore, our entire subject sample was made up of active, competent, highly educated individuals who might be drawn equally to other activities such as volunteer work or creative writing. Yet, our results indicate that, with the exception of public speakers, the performance of individuals participating in other activities, those which do not provide specific practice in working memory or reasoning, did not show an advantage over the performance of nonparticipants.

The lack of a difference in both education and vocabulary between the bridge players and nonplayers suggests that previous general ability levels of the players and nonplayers were similar. It might be argued, however, that individuals age at different rates and that education and vocabulary, while rough indicators of previous ability levels, provide inadequate information about an individual's current status. One of the most widely accepted hypotheses of aging is the slowing hypothesis, that a generalized slowing in the nervous system is central to age-related deficits in cognition (Birren, Woods, & Williams, 1980; Salthouse, 1985). Because speed of behavior is thought to be an indication of the efficiency of central nervous system functioning, age-related degenerative changes in the brain should be reflected in slower responses in RT tasks. If those individuals who chose to play bridge had undergone fewer age-related degenerative changes, they should also have been superior to the nonplayers in measures of RT. However, our results show that the bridge players did not differ from the nonplayers in any RT measure.

In summary, there are two possible explanations for the results of the present study. One possibility is that the experience of playing bridge has helped to delay the decline in reasoning and working memory that typically accompanies aging. On the other hand, previous work of Charness, suggesting that working memory skills are task specific, points to the other possibility that the bridge players were initially an unusually able group who chose to play bridge precisely because of their superior abilities. The correlational data of the present study do not allow us to resolve this issue. However, the question raised by the study is an important one that needs further investigation. A life-style variable, such as bridge playing, does not readily lend itself to an experimental approach. The most appropriate solution would be a longitudinal study comparing change in performance of bridge players and nonplayers over time and looking at the characteristics of dropouts. Such a study would enable us to see whether the performance of bridge players is more stable over the years than the performance of nonplayers.

Perhaps because of the difficulty in establishing causal relations from what must of necessity be correlational data, the relation of life-style activities to cognitive performance has received little attention. We believe this area of research is important not only to increase our understanding of the variables influencing cognition in the elderly, but also because of its practical value in suggesting ways in which cognitive functioning might be enhanced.

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