The Relationship of Game Playing to Intellectual Ability in Old Age*

by

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This study examined relationships between cognitive functioning and game playing ability in the elderly. The sample included 111 individuals from a Florida retirement community, ranging in age from 67-93 years (mean age = 77.8) Subjects were assessed on General Memory, General Speed, Crystallized Intelligence, Fluid Intelligence, and performance on two Jigsaw Puzzles and two Crossword Puzzles. Accuracy in working jigsaw puzzles was positively associated with fluid intelligence and frequency of working puzzles and negatively associated with age. Accuracy in crossword puzzles was positively associated with crystallized ability, speed, and frequency of working puzzles. The influence of education on crossword puzzle accuracy was moderated by crystallized intelligence.

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Introduction

Whether or not cognitive abilities are associated with the elderly's game playing behavior is of interest to both researchers and older adults alike. Why is this of interest? As people age, leisure activities begin to play an increasingly important role in the lives of these older people (Gordon & Gaitz, 1976). Game playing is one popular class of leisure activities enjoyed by the elderly. However, little is known about individual differences that make the elderly more or less likely to play games regularly and skillfully. This study examined the short-term longitudinal relationship between personal variables, cognitive ability, and actual game playing. The psychometric abilities of memory, speed, fluid, and crystallized abilities were examined as correlates of the frequency of working Jigsaw and Crossword Puzzles, and also as correlates of the accuracy of performance.

It has been argued that playing particular games taps the same cognitive skills as those measured by psychometricians. For example, Tosti-Vasey, Willis, Christina, and Jay (1987) found that the frequency of playing strategy games, pencil-and-paper word games, and the game of Solitaire were all significant predictors of fluid intelligence. They also found that frequency of playing risk-taking games was predictive of crystallized intelligence. The game of Bridge has also been shown as an activity requiring the exercise of both working memory and reasoning ability (Clarkson-Smith and Hartley, 1990).

Crossword and jigsaw puzzles are among the most frequently played games by older adults (Tosti-Vasey et al., 1987). These two games require different skills in order to successfully complete the puzzles. Verbal fluency and recognition of vocabulary are skills necessary to successfully complete a crossword puzzle. These skills are part of crystallized abilities. In contrast, a jigsaw puzzle consists of irregularly cut pieces that are fitted together to form a picture. Accuracy in completing jigsaw puzzles requires a person to look at abstract shapes, to find shapes and patterns that parallel each other, and then to join those shapes together. This skill requires one to rotate figures and associate these figures together in a structure that eventually makes sense. These are the factors that make up the ability of fluid intelligence. We thus hypothesized that crystallized abilities are a salient predictor of crossword performance and that fluid abilities are a salient predictor of jigsaw puzzle performance. Furthermore, the expertise and training literature indicates that task familiarity (practice) is related to task performance level (Denney, 1982; Willis, 1990). Thus, we expect for both games that the frequency of game playing is related to accuracy of game playing.

Method

Subjects

The sample included 111 individuals living independently in a Florida retirement community (44 males and 67 females). The mean educational level was 15.2 years (*s.d.* = 2.4, range = 7 - 22 years). The mean age was 76.8 years in 1990 (*s.d.* = 5.6, range = 67 - 93 years). Subjects rated their general health, vision, and hearing on six-point Likert scales (1 = very good, 6 = very poor). The mean health self-rating was 1.8 (*s.d.* = 0.8), the mean vision self-rating was 2.1 (*s.d.* = 1.1), and the mean hearing self-rating was 2.3 (*s.d.* = 1.1). Average annual income for this group was between $24,000 and $27,999, ranging from $4,000 to over $50,000. The majority (79.1 percent) held professional or semi-professional jobs prior to retirement.

There were some significant differences in personal characteristics by gender. Men had a significantly higher level of education (x = 16.3 years, sd = 2.2, $t(109) = 4.10$, $p < .001$) than did women (x = 14.5 years, sd = 2.3). Self-reported hearing was poorer for men (x = 2.6, sd = 1.1; $t(109) = 2.2$, $p < .05$) than for women (x = 2.1, sd = 1.1). Average annual income was significantly higher for men (x = 13.2, sd = 2.5, $t(108.8) = 2.1$, $p < .05$) than women (x =

12.0, sd = 3.6). There were no significant differences by gender in age or self-reported health or vision status.

Measures

Cognitive Ability Measures. Confirmatory factor analyses of a battery of 15 cognitive ability tests resulted in four primary mental-ability factors. The four ability factors were: General Memory, General Speed, Crystallized Intelligence, and Fluid Intelligence. Factor scores were computed for each of four ability factors. See Table 1 for the relationship between these tests and the first- and second-order abilities.

Insert Table 1 about here.

Two tests (Number Span and Word Span) make up the ability of General Memory. Three tests (Finding A's, Number Computation, and Identical Pictures) make up the primary mental ability (PMA) of Perceptual Speed and two tests (Addition Odd and Addition Even) make up the PMA of Number; these two primary mental abilities make up the ability of General Speed. Two tests (Culture Fair and ADEPT Culture Fair) make up the PMA of Culture Fair, two tests (Figure Rotation and Object Rotation) make up the PMA of Space, and two

tests (Word Series and Letter Series) make up the PMA of Induction Reasoning. These three primary mental abilities make up the ability of General Fluid Intelligence. Finally, two tests (Vocabulary and Verbal Meaning) make up the ability General Crystallized Intelligence.

Game-Playing Performance and Frequency. Subjects' performance on two crossword and two jigsaw puzzles was assessed. A *Leisure Activities Survey* was administered to assess subjects' frequency of playing a variety of games; detailed questions concerning the subjects' frequency of playing Jigsaw Puzzles and Crossword Puzzles were included in the survey. Questions included were: (1) How often participants did crossword and jigsaw puzzles, (2) how many puzzles of each game they completed in a week and (3) how much time they spent weekly working on the respective games. For crossword puzzles, a scale was formed from these three items. For jigsaw puzzles, only one individual reported working on jigsaw puzzles at least weekly; thus a scale could not be formed. Hence, the item "How often do you work on jigsaw puzzles?" (1=Never, 6=Daily) has been used as a measure of jigsaw puzzle frequency.

Jigsaw Puzzles. Participants were administered a 100 piece "easy" and a 100 piece "hard" jigsaw puzzle. The "easy" puzzle was made up of medium-size (2-3 cm. by 2-3 cm), contrasting, brightly-colored pieces. The "hard" puzzle was made up of medium size (2-3 cm. by 2-3 cm.), low contrasting, neutral-tone pieces. Both pictured felines (a domestic cat and a tiger). Participants were given 21 minutes (three seven-minute time segments) to complete as much of the puzzle as possible. At the end of each seven-minute time segment, participants stopped and the test administrators counted the number of pieces placed into the puzzle. The total number of pieces correctly placed in both puzzles is the measure of jigsaw-playing ability.

Crossword Puzzles. Participants were administered an 88-word "easy" and a 92-word "hard" crossword puzzle. The "easy" puzzle also contained more common words and definitions (e.g., "we" for the definition "you and I") than did the "hard" puzzle (e.g., "pack" for the definition "compress"). Participants were given 21 minutes (three seven-minute time segments) to complete as much of each puzzle as possible. At the end of each seven-minute time segment, participants were stopped and told to switch pencil colors (regular lead, red, and blue). The number of words fully and accurately completed in the across and down positions at the end of 21 minutes for each puzzle was determined. The total number of words correctly completed across both puzzles is the measure of crossword-playing ability.

Personal Data. Demographic variables, including age, gender, education, occupation, and self-rated health questions were included in this survey. In addition, data on use of prescriptions and medical aid devices (e.g., hearing aids) was gathered to obtain further information on vision, hearing, heart conditions, and general health problems.

Procedures

Data were collected in 1990 and 1991. Ability data and personal data were collected in 1990. Games data were collected in 1991. The ability data were collected over two timed sessions totalling approximately three hours. The personal questionnaire was given to participants as part of a take-home packet to complete and return by the second session. The games data were collected as part of two testing sessions totalling approximately three hours. One jigsaw and one crossword puzzle were worked during each session. One "easy" and one "hard" puzzle were worked during each session. For example, subjects worked a hard jigsaw and an easy crossword puzzle in Session 1. In Session 2, the same subjects worked an easy jigsaw and a hard crossword puzzle. Half the subjects received the hard jigsaw in Session 1 and the other half received the easy jigsaw puzzle in Session 1.

Results

Correlational analysis of the personal and ability variables with the games variables was conducted to examine the relationship of all variables with each other without consideration of mediation. Table 2 presents these correlations.

Insert Table 2 about here.

Path analyses were conducted separately for crossword and jigsaw puzzles to examine the influence of personal variables and cognitive abilities (memory, speed, and fluid and crystallized intelligence) on the puzzle variables of frequency and accuracy. Of interest were whether the effects of personal variables would be moderated by the influence of cognitive factors. Path (beta) coefficients were estimated using LISREL 7 (Joreskog and Sorbom, 1989).

The first model estimated for each type of game was a fully recursive model. Demographic and health variables were estimated as predictors of all ability and game-playing variables. In addition, cognitive abilities were estimated as predictors of frequency and of accuracy of game playing. Frequency was estimated as a predictor of game-playing accuracy.

Inspection of the estimated beta values determined which paths were significant. The final model for each game was then estimated, in which paths that were significantly greater than zero ($p < .05$) were retained. Figure 1 presents the reduced model for Crossword puzzles, Chi Square Goodness of Fit (42) = 29.83, $p = .920$, and Figure 2 presents the reduced model for Jigsaw puzzles, Chi Square Goodness of Fit (44) = 41.01, $p = .601$.

Insert Figures 1 and 2 about here.

We hypothesized that crystallized abilities would be a salient predictor of crossword performance and that fluid abilities would be a salient predictor of jigsaw puzzle performance. We also expected that the frequency of game playing would be related to accuracy of game playing. As shown in both figures, the pattern of significant paths is generally consistent with the hypothesized structural equation model. Accuracy of playing either game is associated with frequency in playing that game. Age and education are directly and significantly predictive of intellectual abilities for both models; however, the relationship between health factors and intellectual abilities was not significant. The following describes the differences in the path models for the crossword and jigsaw puzzle variables.

Crossword Puzzles

Accuracy in working crossword puzzles was positively and directly associated with speed and crystallized intelligence. Frequency of working crossword puzzles was directly and positively associated with crystallized intelligence and negatively associated with education. The influence of age on the puzzle variables was moderated by its impact on the cognitive abilities. In contrast, education was directly (negatively) associated with frequency, but education's influence on accuracy was moderated by its impact on crystallized intelligence.

Jigsaw Puzzles

Accuracy in working jigsaw puzzles was directly associated with frequency of doing jigsaw puzzles and fluid abilities. Frequency of working jigsaw puzzles was directly associated with speed. The negative influence of age on the puzzle variables was moderated by its impact on speed.

Summary

Two types of game playing--crossword puzzles and jigsaw puzzles--were examined to see whether or not cognitive abilities facilitate or aid people in playing games in late life. In addition, health impairment (general health impairment, vision impairment, hearing impairment, and cardiac impairment)

was examined to determine if these factors might have a detrimental effect on game playing.

Accuracy in working jigsaw puzzles was positively associated with fluid intelligence and frequency of working puzzles and negatively associated with age. Accuracy in crossword puzzles was positively associated with crystallized ability, speed, and frequency of working puzzles. The influence of education on crossword puzzle accuracy was moderated by crystallized intelligence.

Three major points can be made as a result of this study. First, cognitive abilities do predict frequency and accuracy in playing games. But the relationship between games and abilities differs by type of game. Crystallized knowledge was a predominant predictor for crossword frequency and crossword knowledge while fluid reasoning was a predominant predictor for frequency and accuracy of working jigsaws. And both games were associated with general speed.

Cognitive Abilities Predicting Game Playing. Accuracy in completing crossword puzzles requires a person to understand a word's definition and then recall that word and its correct spelling. This skill requires knowledge of vocabulary and verbal meaning of that vocabulary. These are both factors that make up the ability of crystallized intelligence.

Accuracy in completing jigsaw puzzles requires a person to look at abstract shapes, to find shapes and patterns that parallel each other, and then to join those shapes together. This skill requires one to rotate figures and associate these figures together in a structure that eventually makes sense. These are factors that make up the ability of fluid intelligence.

The performance sessions were time-limited--21 minutes to complete each puzzle. Thus, individuals who could more quickly associate shapes or crossed words were more likely to complete the games more accurately.

<u>Frequency and Predicting Accuracy of Game Playing</u>. Frequency of working either puzzle predicted performance for that particular type of puzzle. Participants who reported that they worked that puzzle more or less regularly performed better on that puzzle. It is remarkable that this relationship always held after controlling for all other variables in the respective models. We interpret this finding as support for the disuse (the "use it or lose it") hypothesis. This hypothesis states that training and practice keep an ability on a high level, whereas disuse makes the ability susceptible to decline. Adopting a disuse perspective has important consequences for the role of remediation or prevention of cognitive decline. The amount and type of activity frequency is somewhat

under one's own individual control. Thus, through the choice of one's activities, one can maintain specialized abilities through pleasurable activities.

<u>The Moderating Effect of Abilities on Age and Education</u>. Age and education's impact on game playing was moderated through their impact on abilities. For jigsaw puzzles, fluid intelligence and speed moderated age's impact on frequency and accuracy of performance; there were no direct links between age or education and performance. For crossword puzzles, speed moderated age's impact on performance while crystallized intelligence moderated education's impact on both frequency and accuracy of performance; in this case, however, education has a direct, but negative impact upon frequency of working crossword puzzles.

The finding that there is both a positive and a negative relationship between education and game playing may at first seem a little incomprehensible. In adulthood, there are many activities that utilize crystallized abilities--crossword puzzles are only one of a wide variety of leisure activities that utilizes this skill. It should first be noted that crossword puzzles are one of the most frequent and common games played in adulthood (Tosti-Vasey et al., 1987). For example, there are entire magazines that focus on crossword puzzles (or a variation of the same--e.g., Anacrostic, Jumbled Words, etc.) and almost every newspaper in this country has a weekly, if not daily, crossword puzzle. Thus, it is not just the highly educated (who are most likely to score higher on crystallized intelligence) who are exposed to and work these puzzles. For those with a higher education, alternative activities may be competing with one's time to work these puzzles. Thus it may be that higher educated individuals more often select another activity, resulting in the direct, but negative relationship between education and frequency of playing. Yet if they do work crosswords, their higher levels of crystallized intelligence compensate for or mediate the relationship to such an extent that accuracy and frequency become positively related to their educational level.

Health and Game-Playing Ability. Finally, we were surprised to find no relationship between any of the health factors and game-playing ability. This is probably a result of the relatively healthy status of this sample. For example, we expected that the vision factor would be related to general speed and thus accuracy in working jigsaw puzzles. This was not true. Upon further inspection of this variable, we found little variance among participants. Seventy percent of the sample reported that their eyesight is either good or very good and 91.9 percent reported taking (either ingesting pills or taking drops) no vision drug (an additional 7.2 percent reported taking only one drug). The same lack of variance

also holds for the other three health factors. It could be that in another, more heterogeneous sample, health would come out as a predictor of abilities and game playing. Further research will be necessary to determine if this is true.

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Table 1. Factors Associated with Cognitive Ability Tests.

General Ability	Primary Mental Ability	Cognitive Test	Source
General Memory	Memory Span	Number Span	Ekstrom et al. (1976)
		Word Span	after Ekstrom et al. (1976)
General Speed	Perceptual Speed	Finding A's	Ekstrom et al. (1976)
		Number Computation	Ekstrom et al. (1976)
		Identical Pictures	Ekstrom et al. (1976)
	Number	Addition Odd	Ekstrom et al. (1976)
		Addition Even	Ekstrom et al. (1976)
General Fluid	Culture Fair	CFR	Cattell & Cattell (1961, 1963)
		ADEPT CFR	Plemons et al. (1978)
	Space	Figure Rotation	Schaie (1985)
		Object Rotation	Schaie (1985)
	Induction	Word Series	Schaie (1985)
		Letter Series	Thurstone (1962)
General Crystallized	Verbal Ability	Vocabulary	Ekstrom et al. (1976)
		Verbal Meaning	Thurstone (1962)

Table 2. Correlations of 1990 and 1991 Personal, Ability, and Games Data.

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Age	1.00													
2. Education	-0.07	1.00												
3. Health Factor	0.03	0.25**	1.00											
4. Hear Factor	0.18	0.09	0.26	1.00										
5. Vision Factor	0.09	0.10	0.12	0.13	1.00									
6. Cardiac Factor	0.08	0.22*	0.32***	0.01	0.16	1.00								
7. Fluid Ability	-0.52***	0.14	-0.08	-0.12	-0.09	-0.02	1.00							
8. Crystallized Ability	-0.15	0.20*	0.04	-0.06	-0.05	0.06	0.58***	1.00						
9. Memory	-0.31***	0.09	-0.01	-0.07	-0.10	-0.08	0.57***	0.39***	1.00					
10. Perceptual Speed	-0.40***	-0.02	-0.13	-0.24*	-0.17	-0.13	0.62***	0.45***	0.38***	1.00				
11. Crossword Frequency	-0.02	-0.10	0.05	0.00	-0.07	-0.01	0.17	0.37***	0.17	0.21*	1.00			
12. Crossword Accuracy	-0.09	-0.05	0.06	-0.07	-0.00	-0.01	0.43***	0.63***	0.29**	0.47***	0.73***	1.00		
13. Jigsaw Frequency	-0.27**	- 0.13	-0.11	0.05	0.05	-0.06	0.28**	0.16	0.10	0.31***	0.18	0.29**	1.00	
14. Jigsaw Accuracy	-0.42***	0.08	-0.15	-0.04	-0.13	0.02	0.50***	0.27**	0.19	0.42***	0.23*	0.31**	0.55***	1.00

* = $p < .05$; ** = $p < .01$; *** = $p < .001$.

Figure 1: Predictors of Crossword Playing Ability: Personal and Cognitive Variables

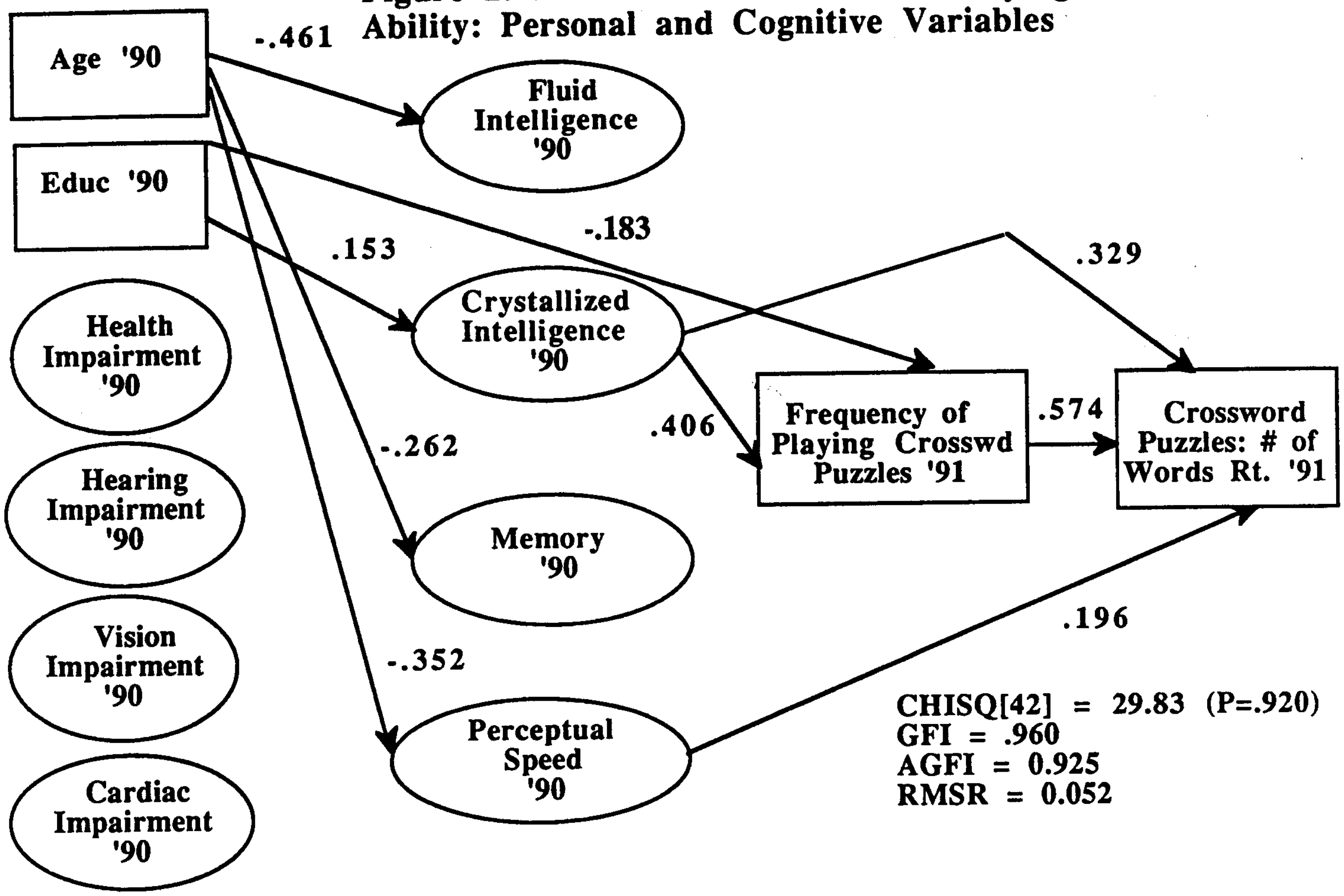

Figure 2. Predictors of Jigsaw Playing Ability: Personal and Cognitive Variables