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Transfer of Spatial Relations Abilities from the Game-Situation to the Test-Situation

Timothy Ward Starkey
Loyola University Chicago

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by

T. W. Starkey

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Vita

T. W. Starkey was born on November 10th, 1942, in Beardstown, Illinois. Upon graduation from Beardstown High School in June of 1960, he enrolled in the physics program at the University of Notre Dame. He graduated from the University of Notre Dame in June of 1964, and then enrolled in the Graduate School of Psychology at Loyola University of Chicago.

Mr. Starkey was a Trainee in Clinical Psychology at the Catholic Charities Guidance Center during his first year in the Graduate School. He is presently serving a clinical internship in psychology at Hines VA Hospital.

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T. W. Starkey

Loyola University of Chicago

<u>Introduction</u>. Visual-perceptual tasks have often been included in tests of intelligence from the early development of psychological tests to the present day (Cronbach,1960). As far back as the Columbian Exposition of 1893, held in Chicago, Joseph Jastrow set up an exhibit in which the visitors to the Exposition were challenged to test their sensory, motor, and simple perceptual processes, as compared to the norms then available (Anastasi, 1957). Oehrn, Ebbinghaus, and Ferrari were other contemporary psychologists who were interested in perceptual, memory, and association tests (Anastasi, 1957).

The present-day Stanford-Binet Intelligence Scale (1960, Form LM) and the Wechsler Adult Intelligence Scale also include tests of perception. Particularly with the Block-counting subtest of the Stanford Binet, spatial-perceptual abilities are tapped (Thurstone, 1938). With the rise of group tests of intelligence during World War II, spatial-perceptual subtests gained more weighting as the need for non-verbal tests of intelligence and reasoning became apparent (Cronbach,1960).

Concurrent with this development, from the first decade of this century on, studies were done on the nature of intelligence itself, in which the statistical interrelations among the various subtest scores made by a large number of people on different tasks were investigated (Cronbach, 1960). Such statistical methodology, as further developed by American psychologists such as L. L. Thurstone (1938; 1947) and T. L. Kelly (1939), have come to be known as " factor analysis " (Boring, 1957).

The data gathered by these statistical procedures have indicated the presence of several relatively independent factors or traits which constitute intelligence, as it is measured by psychological tests (Thurstone, 1938). Some factors or traits, such as verbal comprehension, verbal reasoning, and numerical abilities, were already well-represented in the standard tests of intelligence. Others, such as spatial and perceptual aptitudes, were touched upon only lightly, if at all (Cronbach, 1960).

Using factor analytic methods, Thurstone (1938) gave 56 tests to students at the University of Chicago, and found six factors to be predominant in intelligence. These factors were Verbal, Number, Spatial, Word Fluency, Memory, and Reasoning. Disregarding the use of the word " intelligence ", Thurstone published a selected set of relatively pure tests to measure these " primary mental abilities." Through factor analysis, it has been shown that Thurstone's Verbal factor is found in vocabulary tests and in tests of comprehension and reasoning. The Number factor appears in simple arithmetic tests, and the Spatial factor deals with visual form relationships. Spatial loading is also found in picture absurdity items, copying-a-diamond items, drawing designs from memory, and in paper-cutting (Cronbach, 1960).

There appear to be several markedly different types of spatial abilities. Comprehending static objects, as in block-counting tasks, seems to involve something very much different from visualizing how an object will look after several orienting rotations have taken place. A visualization factor is found in tests such as the Stanford-Binet paper-folding and in some of Thurstone's tests where the subject must visualize how a figure will look when rotated (Cronbach, 1960).

This brief history of the gradual inclusion of spatial relations items in tests of intelligence or mental ability serves to illustrate the importance of school developing this ability as thoroughly, and as rapidly, as possible. Implicit throughout these various standardized tests is the assumption that ability in spatial relations develops incrementally in proportion to a person's chronological age up to a certain developmental plateau, at which point the overall rate of intellectual growth levels out (Cronbach, 1960).

It is this implicit assumption which has suggested the present experiment. Given the natural propensity of children to play games that offer them the opportunity for exercise of their imaginative and strategic resources, it seemed possible that the playing of an interesting spatial relations game would facilitate the transfer of ability from spatial game-playing to that which is measured by standardized tests of spatial relations abilities.

Purpose. It is the purpose of this experiment to test the hypothesis that transfer of learning of spatial ability would occur from the playing of a spatial relations game to a standardized test of spatial relations abilities.

Related Literature

Much previous work has been in the study of the transfer of learning. Typically, the transfer of learning experiment involves an investigation of the effect of a specifiable prior experience upon the learning of a given test activity (Barlow, 1937 ; Osgood, 1949). Practice on one task may have a facilitating effect on another task even though the behavior required in the two tasks is topographically different, and may, in fact, even be incompatible (Mandler, 1962). Further, practice on the training task may sometimes produce more gain on some very different criterion tasks than would a comparable amount of practice on the criterion task itself (Grose and Birney, 1963).

Most experiments that have been done to date on transfer of learning deal with either a motor task-to-motor task, word list-to-word list, or verbal training-to-motor task type of transfer (Barch, 1963; Ebenholtz, 1963; Hall and Treichler, 1956; Haplin, 1959; Judd, 1908; Lawrence, 1952; Maltzman, Bogartz, and Breger, 1958; McCormack, 1958; Morgan, 1956; Wiener, 1963). Few experiments very similar to the present one have been reported in the literature; none have been identical.

Harlow (1949) writes that the learning of primary importance to man is the formation of learning sets. Eckstrand (1954) supports this position, and Mattson (1965) found evidence of a learning-to-learn type of transfer effect.

Evidence of positive transfer of learning along dimensional lines has been reported by some investigators (Cooke, 1959; Riopelle and Rogers, 1956). Cooke, investigating the cumulative transfer in the reproduction patterns on the Toronto Peg Board, reports that spatial position is one of the three major variables that bear a constant directional relation to the amount of transfer observed. Riopelle and Rogers found that giving a differential response to stimuli in one dimension sharpened the generalization gradient in another dimension.

Haslerud and Meyers (1956) found that transfer is maximized when the principles involved are independently derived by the subjects, as opposed to when they are directly given to the subjects by the experimenter.

As distinguished from other types of transfer of learning experiments characteristically reported in the literature, the present experiment is concerned with the transfer of spatial conceptualizing ability from a game-situation to the test-situation. This is to say, the present experiment does not essentially involve transfer of either a motor or memory nature; rather, it is concerned with whether or not the ability to perceive spatial relationships can be sufficiently improved such that a standardized test of spatial abilities is able to reflect the increase of ability.

Evidence of positive transfer of non-spatial concepts is reported in the literature (Drennen, 1963; Gladis, 1960; Lawrence, 1949; Logstaff, 1954; Wittrock and Keislar, 1965). Contrary evidence is also reported in the literature (Anderson and Anderson, 1963; Hoffman, Burke, and Maier, 1963).

Hypothesis. The repeated playing of a spatial relations game will significantly improve performance on a standardized test of spatial relations in latency-age boys.

Method

Subjects. The subjects (Ss) for this experiment were boys living in Angel Guardian Orphanage, who ranged in age from eight years to eleven years. They had Otis IQ scores ranging from 82 to 118, with the Experimental Group mean at 99.0 and the Control Group Mean at 97.2 . All children were at age-appropriate grade levels in school. There were 28 boys in the Experimental Group, and 21 boys in the Control Group. The selection and treatment of the Control Group was conducted nine months after the completion of the experimental phase.

Both groups were chosen such that their age distributions were similar, and such that the differences between the means of the two groups on the pre-tests were not statistically significant at the .05 level. Table 1 contains further relevant comparisons of the two groups.

Apparatus. The spatial relations game played by the Experimental Group is the Parker Brothers game of Qubic. Qubic is a three-dimensional tic-tac-toe game, constructed of four clear plastic decks, each with a four-by-four matrix stamped on it, with decks suspended one above the other. The game is played by four players, each with his own color of chips, and the winner is the player who gets four chips

Table 1.

Pre-Test Results

	Experimental	Control	t test
WL :	N = 28 M = 14.9 SD = 8.88 S^2 = 78.9	N = 21 M = 15.4 SD = 5.48 S^2 = 30.4	t = .242 df = 47 Not Signif-icant at .05
PT :	M = 15.5 SD = 4.32 S^2 = 18.7	M = 17.4 SD = 2.53 S^2 = 6.40	t = 1.92 df = 47 Not Signif-icant at .05
ST :	M = 15.3 SD = 4.7 S^2 = 22.1	M = 17.0 SD = 3.49 S^2 = 12.8	t = 1.45 df = 47 Not Signif-icant at .05

in a straight line in any direction or dimension.

The game played by the Control Group is named the " Win A Prize " game (WAP), and is very similar to bingo. Each subject is given a game-sheet upon which are the names of ten popular sports cars. The game-sheets are distinguished only by the difference in color of the upper right-hand corner. The Experimenter rolled a die, each surface of which was a different color, each corresponding to three or more of the game-sheets, and called out the name of the top sports car on the game-sheet with the color just rolled. Any subject having that color would mark through the car named with a pencil. The Experimenter would then proceed to the next car on the list, calling it out with a color rolled on the die. By controlling the number of different colors in circulation, the Experimenter was able to control how many subjects won per game. Winning consisted of marking off the previously designated number or combination of cars on the game-sheet.

Measures. The measure of spatial relations used as pre-test and post-test criterion in this experiment was the Science Research Associates Primary Mental Abilities test (PMA), Age 7 through 11, Form AH. In addition to the Space test (ST), the Word List test (WL) and the Word Picture test (PT) were also administered as measures of transfer of non-spatial abilities. The Technical Supplement manual furnished by the company lists the reliability coefficients of the three subtests as follows : r for WL = .942 ; r for PT = .881 ; r for ST = .788 . The specific intercorrelations among the three subtests are listed as : WL to PT = .616 ; WL to ST = .175 ; PT to ST = .257 .

Procedure. The treatment of the Experimental Group was as follows : for seven consecutive days the subjects played Qubic for one hour per day, with each subject keeping track on tally sheets of his wins and losses. Since it was stated at the beginning of the initial game-period that after the final practice session the best players would receive nice prizes, the competition was very keen. The Experimenter carefully recorded the attendances of each subject, and all subjects participated in exactly seven game sessions. No explanation of the experimental nature of the project was given; the subjects were simply told that the Experimenter wanted to see how proficient they could become at playing the game in a week's time. On the eighth day, all 28 subjects were retested, and prizes were awarded to all subjects, with the nicer prizes going to those who had won the most games.

The Control Group received much the same treatment as did the Experimental Group. For six consecutive days these 21 subjects played WAP for 45 minutes a day. Approximately two complete games were able to be played per session, and hence there were approximately eight to twelve winners per day. Each winner was immediately given a bakery-fresh doughnut as his prize. As might be expected, enthusiasm ran high, and it very soon became necessary to devise means for detecting cheating. The cheating problem, which was beginning to disrupt group morale, was quickly solved, and did not appear to effect the overall Control Group performance. On the seventh day, the entire group was retested, and additional pastries were given to each subject. In addition to expressing the Experimenter's gratitude for their cooperation, the last day's pastries served to maintain group attention for the final test-taking.

Results

Table 1 presents the results of the initial testing of the two groups. A two-tailed t test indicates that there are no statistically significant mean differences at the .05 level between the two groups.

Table 2 presents the post-test changes for the two groups. It is evident that, with a two-tailed t test, the Experimental Group WL and PT changes are significant at the .05 level, and the Experimental Group ST changes are significant with a one-tailed t test at the .05 level. The Control Group WL changes are significant at the .05 level, while the PT and ST changes are not significant at the .05 level, with two-tailed t tests. For both groups combined, the Pearson Product Moment correlation coefficients for the WL test were .864, for the PT test were .820, and for the ST test were .576. The Pearson Product Moment correlation coefficient for the Experimental Group alone for the WL test was .915 , for the PT test was .825, and for the ST test was .428.

Table 3 presents the post-test comparisons of the two groups. It is evident that there are no significant differences between the two groups on any of the three subtests.

Table 4 presents the t test analyses of the difference between the Experimental-Group individual change scores and the Control-Group individual change scores. A two-tailed t test for non-correlated data revealed no significant differences at the .05 level of significance. The change-score differences did approach significance, however, at the .10 level. It is felt that this last test of significance of difference bears most directly upon the hypothesis being tested (see McNemar, 1962, pages 86-88).

Table 2.

Experimental and Control Group
Changes From Pre-test to Post-test

	Experimental (N = 28)			Control (N = 21)		
	Pre-test	Post-test	t test	Pre-test	Post-test	t test
WL :	M= 14.9 SD= 8.88 S^2= 78.9	M= 17.0 SD= 7.95 S^2= 63.0	t= 2.26 Significant at .05 df=27	M= 15.4 SD= 5.48 S^2= 30.4	M= 17.6 SD= 5.09 S^2= 25.1	t= 2.55 Significant at .05 df= 20
PT :	M= 15.5 SD= 4.32 S^2= 18.7	M= 17.3 SD= 5.38 S^2= 28.8	t= 3.26 Significant at .05 df= 27	M= 17.4 SD= 2.53 S^2= 6.40	M= 17.8 SD= 2.34 S^2= 5.48	t= .747 Not Significant at .05 df= 20
ST :	M= 15.3 SD= 4.7 S^2= 22.1	M= 17.1 SD= 4.51 S^2= 20.3	t= 2.2 Significant at .05 df=27	M= 17.0 SD= 3.49 S^2= 12.8	M= 17.5 SD= 3.71 S^2= 13.8	t= .791 Not Significant at .05 df= 20

Table 3.

Post-test Results

	Experimental	Control	t test
WL :	M=17.0 SD=7.95 S^2=63.0	M=17.6 SD= 5.09 S^2= 25.0	t= .321 df= 47 Not Significant at .05
PT :	M= 17.3 SD= 5.38 S^2= 28.8	M= 17.8 M= 2.34 S^2= 5.48	t= .439 df= 47 Not Significant at .05
ST :	M= 17.1 SD= 4.51 S^2= 20.3	M= 17.5 SD= 3.71 S^2= 13.76	t= .341 df= 47 Not Significant at .05

Table 4.

t Test of Differences Between Experimental-Group Individual Change Scores and Control-Group Individual Change Scores

	Experimental	Control	t test
WL :	M= 2.14 SD= 4.90 S^2= 24.0	M= 2.2 SD= 5.0 S^2= 25	t= .042 Not Significant at .05 for df= 47
PT :	M= .856 SD= 2.86 S^2= 8.20	M= .428 SD= 2.95 S^2= 8.70	t= .510 Not Significant at .05 for df= 47
ST :	M= 1.68 SD= 4.18 S^2= 17.5	M= .524 SD= 2.32 S^2= 5.38	t= 1.24 Not Significant at .05 for df= 47

Discussion

As groups, it is evident that there were no initial significant differences (see Table 1). Given the two treatments, the pre- to post-test differences were significant for both groups on the WL test. The reasons for this are unclear ; some improvement in score is expected through test-retest factors, such as item-recall and attention-increase. The pre- to post-test changes on PT and ST were significant for the Experimental Group, but not for the Control Group. Additionally, the Pearson Product Moment correlation coefficient for all Ss were as follows : WL= .864, PT= .820, and ST= .576. Taking only the Experimental Group, however, the correlation coefficients were WL= .915, PT= .825, and ST= .428. The implications here are that whatever changes did occur were unsystematic, and that the ST test was susceptible to the Experimental Group treatment in terms of reliability, to a greater degree than were the WL and PT tests.

Even though the Experimental Group pre- to post-test changes were significant for the ST test, the post-test mean difference between the two groups were not significant. The reasons for this are unclear, but it is likely to be largely due to initial near-significant differences which approached, but did not reach, significance at the .05 level.

It has been previously stated that the statistical analysis which appears most appropriate to the basic design of the experiment is the t test of the difference scores from pre- to post-test for the two groups. The rationale for this is two-fold : first, what the hypothesis essentially seeks to determine is not really the significance of Experimental Group changes per se, but rather whether or not the individual differences which do occur, taken by themselves, are significantly different from one treatment-group to another, and secondly, in a very real sense, the Control Group is not really a " control group." What actually is being compared is not a treatment-group with a non-treatment group, but really one type of treatment (ie. spatial game-playing) with another type of treatment (ie. neo-bingo) on two very similar samples of subjects. While none of these t tests for non-correlated means achieved significance at the .05 level, the ST test significance of score-change does approach significance at the .10 level. Neither the WL test nor the PT test show any tendency toward approaching significance at the .10 level (see Table 4). While this cannot be taken as unqualified support for the hypothesis, it does cautiously suggest that replication of this experiment with more sensitive test-criterion bearing more face-similarity to the game itself, and with more practice periods, might afford more sufficient opportunity for statistically significant transfer effects to manifest themselves through the test-criterion.

In conclusion, brief attention should be given to the possible influence that one group receiving immediate (doughnut) reward while the other received rewards only at the end of the week's game-sessions might have had on attention and cooperation variables. It was observed that the Control Group responded to the immediate pastry reward with an obvious increase in cooperation, which was hoped would increase the number of games played per session. Group morale appeared to be highest when approximately eight players won per game, and was seen to decline markedly when only one or two players won per game. The Experimental Group, by the last few game-sessions, needed frequent reminders that they were playing for prizes. The Experimenter had to increase the number of prizes (inexpensive toys and Qubic games) from only a few, to a minimum of one per subject, with the best players getting additional prizes. In short, then, it would appear that immediate reward, even if only a doughnut, is more effective in eliciting cooperation and attention in latency-age boys than is delayed reward, even if the delayed rewards are in themselves more desirable than the immediate rewards.

Summary

The hypothesis tested in this experiment was that intensive, prolonged spatial-game-playing would significantly improve performance on a spatial-test criterion. Using as subjects grade-school boys living in a residential child-care home for non-delinquents, an Experimental Group (N= 28) was matched with a Control Group (N= 21) in terms of age, grade-placement, Otis IQ, and scores on three test-criteria, one of which is a spatial-relations test. Both groups were first pre-tested, subjected to a week of game-playing, and then re-tested. The Experimental Group played a spatial relations game, and the Control Group played a bingo-like placebo game. The results did not show any significant differences between the two groups in post-test scores at the .05 level, but did approach significance at the .10 level on the spatial test. It is concluded that replication using a more sensitive test-criterion bearing more face-similarity to the spatial game, and providing for a longer period of game-playing, is advisable.

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Abstract

The hypothesis tested in this experiment was that intensive, prolonged spatial-game-playing would significantly improve performance on a spatial-test criterion. Using as subjects grade-school boys living in a residential child-care home, an Experimental Group (N= 28) was matched with a Control Group (N= 21) in terms of age, grade-placement, Otis IQ, and scores on three test-criteria, one of which was a spatial relations test. Both groups were first pre-tested, subjected to a week of game-playing, and then re-tested. The Experimental Group played a spatial relations game, and the Control Group played a bingo-like placebo game. The results did not show any significant differences between the two groups in post-test scores at the .05 level, but did approach significance at the .10 level on the spatial test. It is concluded that replication using a more sensitive test-criterion bearing more face-similarity to the spatial game, and providing for a longer period of game-playing, is advisable.

APPROVAL SHEET

The thesis submitted by T. W. Starkey has been read and approved by the director of the thesis. Furthermore, the final copies have been examined by the director and the signature which appears below verifies the fact that any necessary changes have been incorporated, and that the thesis is now given final approval with reference to content and form.

The thesis is therefore accepted in partial fulfillment of the requirements for the degree of Master of Arts.

8 June 67
Date

Patricia M. Barger Ph.D.
Signature of Adviser