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Sex Differences in Spatial Ability and Spatial Activities[1]

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Explanations of sex-related differences in spatial ability emphasizing the role of sex-differentiated experience have not been supported by direct measurement of spatial activities during adolescence, the period when these differences seem to increase. The present research involved development of a scale to measure the spatial experience of adolescents and adults. In Study 1, a list, as complete as possible of adolescent activities was compiled and given to undergraduate judges for ratings of involvement of spatial skills and sex-typing. Judges also indicated whether they had participated in each activity. Activities considered spatial by 75% or more of the judges were used to develop a spatial experience questionnaire. Judgments of the spatial nature of tasks were positively correlated with judged masculinity and with greater male than female participation. In Study 2, participation in spatial activities by undergraduates was correlated with spatial ability as measured by the Differential Aptitude Test. The activity questionnaire should prove useful in studying the development of spatial ability in adolescents and adults.

Sex-related differences in spatial ability have been the focus of much recent research (for reviews, see Harris, 1978, 1981; Wittig & Petersen, 1979). Hypotheses to explain the differences abound, and include genetic, hormonal, lateralization, and experiential accounts. Evidence relevant to explaining the sex difference in terms of differences in environment and experience with spatial activities has come from several sources (for instance, sex differences in responsiveness to training; Connor, Serbin, & Schackman, 1978; Vandenberg, 1975).

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Direct measurement of spatial experience has been rarer. Connor and Serbin's (1977) observations of preschool play showed that performances of preschoolers on WPPSI Block Design and Preschool Embedded Figures Tests were positively correlated with masculine activity preferences and negatively correlated with feminine activity preferences for boys, but not for girls. The masculine activities included many apparently spatial pursuits such as playing with blocks, Lincoln Logs, and a cube puzzle. A subsequent study showed that preschool children of both sexes who preferred masculine to feminine activities had higher WPPSI Block Design scores than those who preferred feminine to masculine activity (Serbin & Connor, 1979). Spatial ability in East African children has been related to distance traveled from home, with boys going farther than girls (Munroe & Munroe, 1971, Nerlove, Munroe, & Munroe, 1971). The sex difference in spatial range for elementary school children has also been found in Western cultures (Saeger & Hart, 1978), although not directly correlated with spatial ability.

Little comparable information exists about participation in spatial activity by adolescents and adults. Such data are important to an environmental explanation of sex differences; although sex differences in spatial ability may begin before adolescence (Vandenberg & Kuse, 1979), there are indications that the difference increases at adolescence (Droege, 1967; Flanagan, David, Dailey, Shaycroft, Orr, Goldberg, & Neyman, 1964; Nash, 1975). An account of this increase in terms of experience would need support from evidence concerning the spatial activities of adolescent males and females.

The literature on sex-related differences in spatial ability frequently refers to activities such as model building, automobile repair, sports, and mechanical drawing as examples of male sex-typed experiences likely to enhance spatial ability (Sherman, 1967). But no consensus exists concerning which of the multitude of adolescent and adult activities are spatial, and to what extent such activities are considered more masculine than feminine. It is certainly possible to point to examples of feminine activities, such as sewing, which seem to involve spatial skills.

McDaniel, Guay, Ball, and Kolloff (Note 1) have developed a questionnaire to assess participation in spatial experiences by adults. Unfortunately, they failed to specify the universe from which the activities were selected or the criteria used to evaluate whether experiences drew on spatial ability. And although they showed that participation was related to self-ratings of spatial ability, they obtained no objective evidence concerning spatial skills. Finally, they did not report data on the sex-typing of the activities in their scale.

The objectives of the present research were, therefore, (a) to compile as complete a list as possible of all activities likely to be engaged in at adolescence, so that certain spatial activities would not be systematically excluded from consideration; (b) to obtain judgments of which activities involve spatial ability, so that a comprehensive list of spatial activities could be drawn up; (c) to obtain judgments of sex-typing and extent of male and female participation, so that the idea that spatial activities are more masculine than feminine could be tested; (d) to examine whether the resulting activity scale was correlated with objectively measured spatial ability. Objectives (a) through (c) were accomplished in Study 1, and objective (d) in Study 2.

STUDY 1

Method

Materials. The three authors generated a list of 231 activities that might occur in a population of high school and college students. They consulted high school yearbooks and junior and senior high school students in an effort to be as inclusive as possible. They also broke down activities into skill levels (e.g., plain knitting, knitting with seams, knitting patterns; beginning and advanced tennis), since it seemed that elementary versions of many activities were not spatial, but more advanced or specialized versions were.

The resulting list was checked for inclusiveness by comparisons with diary data gathered by Lever (1978), who had fifth graders keep detailed records of their activities during a week of winter. This was a prepubescent population and excluded summer activities, but the data provided some check of the completeness of the list. The list included 73% of the frequent activities (mentioned 10 times or more) in Lever's diaries. The activities missed were "childish" (e.g., doll play, hide and seek) or nonspecific (e.g., play in park, fantasy) and were therefore not added. There were 97 activities on our list not mentioned by the fifth graders, predominantly more "adult" activities (e.g., poker, metalworking, photography) and summer activities (e.g., sailing). These were retained for use with an adolescent population.

Subjects and Procedure. Undergraduates (45 males and 61 females) were recruited from introductory psychology classes to serve as raters in exchange for points towards their final grade. To ensure that they understood the concept of spatial ability, they were given standard instructions for the Spatial Relations Test of the Differential Aptitudes Test (DAT), which requires picking which of four three-dimensional forms can be made by folding a specified two-dimensional form. They did two examples and five problems from the test, to obtain direct experience of spatial mental processes. They were then asked to classify each of the 231 activities as requiring or not requiring spatial ability (dichotomous choice), as traditionally masculine or feminine (dichotomous choice), and to indicate for each if they had participated personally.

Results

The classifications of activities as spatial versus nonspatial and masculine versus feminine sex-typed were tabulated separately for males and females who had participated or not participated in each activity. Thus, percentages of participating men, participating women, nonparticipating men, and nonparticipating women who considered each activity spatial were obtained, as well as percentages who considered each activity masculine. The percentages for all 231 activities were then correlated across the four groups, to determine if judgments were similar for males and females and participants and nonparticipants.

Judgments of sex-typing were found to be highly reliable across both sex of rater and participation level (*r*s ranged from .92 to .93). Judgments of spatial involvement were also reliable across sex and participation level, although at lower levels (*r*s ranged from .75 to .84). The data for the four groups were thus collapsed. A list was compiled of activities on which 75% or more of the judges agreed that spatial ability was involved. There were 81 such activities, 40 classified as masculine by 75% or more of the judges, 21 classified as feminine by 75% or more of the judges, and 20 not considered sex-typed (i.e., opinion was divided as to whether the activity was masculine or feminine). The complete list is shown in Table I.

Correlations were computed among the following measures for the 231 activities: percentage of judges who believed the activity involved spatial ability, percentage of judges who believed the activity was masculine sex-typed, the percentage of males who had participated in the activity, the percentage of females who had participated in the activity, and the difference between male and female participation. Higher proportions of masculine sex-typing judgments were correlated, as would be expected, with larger excesses of males over females in reported participation, $r = .69, p < .001$. While some of this relationship may be due to raters being influenced in reporting participation by having just rated activities as masculine or feminine, this correlation was not the main focus. More importantly, higher proportions of judgments of spatial involvement were correlated at low but significant levels, with more masculine sex-typing judgments, $r = .24, p < .001$, and with greater male than female participation, $r = .15$, $p < .05$. That is, more spatial activities were considered more masculine, and there was greater male than female participation in activities thought to require spatial ability. People of both sexes participated less in spatial activities than in other activities; the correlations of judgments of spatial involvement with percentage participation were $r = -.26$, $p < .001$, for males and $r = -.39, p < .001$, for females. Thus, spatial activities appear to be relatively unpopular among this undergraduate group.

Discussion

The results of Study 1 show some consensus between males and females and between participators and nonparticipators concerning which of a large population of activities draw on spatial skill. Such pooled judgments seem to provide a better basis than do the intuitions of individual authors for selection of experiences that merit study in work on spatial ability.

Table I. Spatial Activities Listed by Sex-Typing

Masculine	Neutral	Feminine
Touch football	Bowling	Figure skating[d]
Tackle football	Softball	Field hockey
Baseball	Advanced tennis[c]	Baton twirling (toss in air)
Basketball	Pingpong[a]	Baton twirling (> 1 baton)
Ice hockey[b]	Volleyball	Water ballet[c]
Advanced racquetball	Beginning racquetball	Gymnastics[b]
Soccer[b]	Dodgeball	Ballet (pirouettes)
Squash[c,d]	Jumping horses	Ballet (choreography)
Darts[c]	Diving	Tap dancc (own routine)
Horseshoes	Frisbee	Disco dancing (with falls)[a]
Archery[d]	Jewelry (mount stones)[a,b]	Pottery (wheel)[d]
Golf	Drawing (three-dimensional)	Embroidery (no pattern)[b]
Hunting[d]	Painting (three-dimensional)	Crochet (with scams)[d]
Target shooting	Leatherwork (with seams)	Knitting (with seams)[a,d]
Rock climbing	Sculpting	Knitting (multicolor)[a]
Canoeing (shooting rapids)	Weaving (design own warp)[b]	Quilting
Sledding (around obstacles)	Photography (adjusting focus)[b]	Tailoring[b]
Skiing (slalom)	Navigate in car	Arranging furniture
Skiing (jumping)[a]	Layout for newspaper, yearbook	Touch typing
Skateboarding	Marching band	Interior decorating
Fencing		Sketch clothes designs
High jumping		
Pole vaulting[a]		
Shooting pool		
Foosball		
Air hockey		
Glass blowing[b]		
Building model planes[b]		
Building train or racecar sets		
Building go-carts[b]		
Juggling[a,d]		
Mechanical drawing		
Car repair		
Electrical circuitry[b]		
Plumbing		
Carpentry[b]		
Make/fix radios, stereos		
Sketch auto designs		
Sketch house plans[b]		
Using compass[b]		

[a] Individual activity positively correlated with DAT for males, $p \leqslant .05$.
[b] Individual activity positively correlated with DAT for females, $p \leqslant .05$.
[c] Individual activity positively correlated with DAT for males, $.05 < p \leqslant .10$.
[d] Individual activity positively correlated with DAT for females, $.05 < p \leqslant .10$.

Two caveats should be noted. One is that consensus of judges does not mean that an activity draws on spatial ability. Controlled experimental observation would be necessary to establish this. But conducting the required studies for 231 (or even 81) activities would be a daunting prospect, and the present methodology seems a useful step towards identifying experiences requiring spatial skill. In Study 2, the correlation of the activities judged to be spatial with measured spatial ability was determined.

A second possible limitation is that use of the DAT in instructions to judges may have limited their decisions to consideration of one type of spatial ability. It is often proposed that spatial tasks contain two factors, spatial orientation and spatial visualization (French, Ekstrom, & Price, 1963). The first factor involves perception of relations between objects in space with the observer as a reference point, and the second mental manipulation of objects independent of the observer as reference point (i.e., where the observer seems removed from the stimuli). The DAT, using these definitions, is a test of spatial visualization; it involves three-dimensional manipulation, as opposed to the two-dimensional transformations required by, for instance, mental rotation tasks. However, factor analysis has not always been able to differentiate orientation and visualization factors (Carroll & Maxwell, 1979). Whether judges would be able to use spatial orientation versus visualization as a basis for differential classification of activities requiring one or the other or both is an issue on which further work is needed.

The sex-typing data show that more masculine activities, whether defined by stereotypes or by actual sex differences in reported participation, are judged to involve more spatial skill than less masculine activities. These correlations are those predicted by an experiential account of sex differences in spatial ability. They are not totally incompatible with other explanations, since if males have more spatial ability for some other reason than differential experience, we might expect that more male activities would involve such skill.

STUDY 2

Method

Undergraduates (22 males and 23 females) from introductory psychology classes participated in Study 2 in exchange for points towards their final grades. In a first session, they were individually administered the Differential Aptitudes Test. At a second session, they were individually administered the experience questionnaire consisting of the 81 spatial activities from Study 1. Pilot work has shown that individual administration is necessary to ensure understanding of tasks and motivation to perform them as accurately as possible. Subjects were asked to indicate their degree of participation in each activity on a 6-point scale, with 1 = never participated and 6 = participate more than once a week (during the season, if relevant).

Results

The correlation of DAT scores with summary activity scores for the total sample was found to be significant, $r = .33, p < .05$; activity thus accounted for 11% of the variance in DAT scores. For females alone, $r = .40, p = .05$, with 16% of the variance in DAT accounted for; for males alone, $r = .18$, *ns*., with only 3% of the variance accounted for. The correlations for the males and females were, however, not significantly different from each other. Correlations for the subscales of masculine, feminine, and neutral activities shown in Table I were compatible with the correlations given above; that is, positive and significant for females, positive and not significant for males.

Males scored higher than females on the DAT, $t(43) = 1.85, p < .05$ by one-tailed test; sex accounted for 5% of the variance in DAT scores. Males participated more in the 40 spatial activities judged masculine in Study 1, $t(38) = 5.02, p < .001$, and females more in the 21 spatial activities judged feminine in Study 1, $t(40) = 5.20, p < .001$. There was no sex difference in reported participation in the 20 activities judged not sex-typed in Study 1, $t < 1$; nor was there any sex difference in total spatial activity, $t = 1.17$.

Correlations of individual activities with DAT scores for males and females were examined, and activities for which significant positive correlations or trends were obtained are indicated in Table I. There were relatively few such correlations for males. For females, significant correlations were observed for three feminine activities, three nonsex-typed activities, and nine masculine activities, including such commonly cited examples of masculine spatial activity as carpentry, electrical circuitry, building model planes, and using a compass.

Discussion

Study 2 shows that the activity scale developed in Study 1 correlates with spatial ability in a college population. Although the fact that the correlation was significant for females and not significant for males might be taken to indicate that this is true only for females, such a conclusion would be premature, since the lower correlation for the males did not differ significantly from that for females.

The correlations are probably attenuated by inclusion of activities judged spatial which may not really be so. Further work is needed to cross-validate the correlations of individual activities with spatial ability obtained here, and to purify and shorten the activity scale. It might also be possible to improve the scale by including school subjects as well as extracurricular activities. Subjects such as mathematics, engineering, and chemistry require spatial ability. For mathematics, this has been substantiated by the work of Hyde, Geiringer, and Yen (1975) and Burnett, Lane, and Dratt (1979). Bennett, Seashore, and Wesman (1974) summarize evidence that the DAT correlates with course grades in drafting, data processing, graphics, and engineering. Since these are generally masculine subjects, sex differences in course taking as well as in out-of-school activities may contribute to sex differences in spatial ability. In fact, the nonsignificant correlation for males in the present study between ability and extracurricular activities could be due to many of the men, including some of those low on the present activity scale, developing spatial ability in an academic context. The women may not be as likely to do this.

A sex difference in spatial ability was evident in this sample, but the sexes did not differ in their overall participation in the 81 spatial activities. Not all of these activities, however, may actually involve spatial ability, as noted above. Of the 15 individual activities correlated with spatial ability for females, 9 were masculine and only 3 feminine. Feminine spatial activities seem to exist, including in this sample gymastics, embroidery not from a printed pattern, and complex tailoring; but there are perhaps not as many of them as there are of masculine spatial activities. Thus, there again seems to be some evidence that more spatial activities tend to be masculine rather than feminine sex-typed. The masculinity of spatial activity may account for the frequent observation that masculine sex-role orientation is associated with higher spatial ability (Nash, 1975; Jamison & Signorella, 1980; Signorella & Jamison, 1978).

The spatial activity scale developed here should be useful in work on the development of spatial ability in an adolescent population. It could be used to assess sex differences in spatial activity (whether they exist and time of appearance) and to examine whether sex differences in spatial activity coincide with the augmentation of sex differences in spatial ability. Cross-lagged correlation in longitudinal samples might be helpful in deciding whether activity affects ability, as required by an experiential account of sex differences in spatial ability, or whether ability affects activity (self-selection). (Rogosa, 1980, should be read for a critique of the cross-lagged correlation technique). If sex-differentiated activity in adolescence predicts sex-differentiated cognitive skills, and if self-selection could be ruled out as an explanation of such relationships, we would have interesting evidence supporting the hypothesis that sex differences in spatial ability are caused by sex-differentiated experience.

REFERENCE NOTE

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