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Research Paper

Gender Difference in Spatial Ability

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ABSTRACT

The present study investigated gender differences in spatial ability using both standardized assessment and real-life perceptual tasks. A total of 70 university students (35 males and 35 females) were assessed using the Spatial Subtest of the Multidimensional Aptitude Battery-II (MAB-II) and two real-world size estimation tasks involving vertical and horizontal spatial perception. Results revealed a statistically significant gender difference in the MAB-II spatial scores, with males outperforming females. However, in the real-life perceptual tasks, the results were mixed. Females showed significantly better performance in horizontal size perception and slightly better, though not statistically significant, accuracy in vertical size perception. These findings suggest that while males may have an advantage in abstract spatial reasoning, females may demonstrate superior spatial perception in ecologically valid, real-world contexts. The study highlights the multifaceted nature of spatial ability and underscores the importance of using diverse measurement approaches. Educational implications and the need for gender-sensitive training programs in spatial skill development are discussed.

Keywords: *Spatial Ability, Gender Difference, MAB-II, Size Perception, Mental Rotation, Spatial Cognition*

Spatial ability, broadly defined as the capacity to understand, reason, and remember the spatial relationships among objects, is a critical component of cognitive functioning. This ability includes various sub-skills such as mental rotation, spatial visualization, and spatial perception (Gardner, 1983). It plays an integral role in a variety of disciplines including architecture, engineering, mathematics, navigation, and sports performance. Spatial cognition is also a predictor of success in STEM-related careers and academic performance (Halpern, 2000). As such, understanding factors that influence spatial ability, including gender, has been the focus of significant empirical interest over the decades.

Gender differences in spatial ability have long been a subject of psychological and educational research. Historically, males have consistently outperformed females in specific spatial tasks, particularly in mental rotation and spatial perception (Voyer et al., 1995; Linn & Petersen, 1985). These gender-based disparities have prompted the development of multiple theoretical frameworks to explain the observed differences. Early explanations

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were grounded in biological essentialism, attributing male superiority in spatial tasks to innate, biological factors such as hormonal influences and brain structure differences. For instance, testosterone has been associated with spatial performance, and certain brain regions such as the parietal lobe have shown structural sexual dimorphism linked to spatial reasoning (Koscik et al., 2009; Hausmann et al., 2000).

Psychoanalytic perspectives, like those of Freud (1910), offered early insights into how gender identity and roles may be internalized during early childhood, influencing later cognitive and behavioral traits. However, with the advent of feminist psychology and sociocultural theories, there was a paradigm shift towards the view that gender is a socially constructed identity shaped by cultural expectations, norms, and roles (de Beauvoir, 1949; Maccoby, 1998). The functionalist perspective, represented by Parsons (1950s), also argued that gender roles evolved to maintain social stability, with women expected to fulfill expressive roles and men instrumental ones.

The psychological understanding of gender differences further evolved with the introduction of cognitive and learning theories. Social learning theory emphasized observational learning and reinforcement in shaping gendered behaviors (Bandura, 1977). Children imitate gender-consistent behaviors exhibited by parents, teachers, peers, and media figures, and are rewarded for conforming to societal gender expectations. Gender schema theory (Bem, 1981) added a cognitive dimension, proposing that children form mental schemas of gender that influence their perception and behavior.

In addition to biological and psychosocial theories, the role of environmental and experiential factors in developing spatial ability is well acknowledged. Research suggests that males and females are socialized differently from early childhood, leading to varying exposure to toys, games, and activities that stimulate spatial thinking (Levine et al., 1999). Boys are more likely to engage in construction toys, puzzles, and video games, which are known to enhance spatial skills. Such gender-stereotyped play preferences are reinforced by parents, educators, and media. Consequently, boys accumulate more spatial experience and training than girls, contributing to performance differences.

Empirical evidence supports the notion that training and experience can significantly reduce or even eliminate gender differences in spatial ability. Baenninger and Newcombe (1989) found that training improves spatial performance for both genders. However, meta-analyses by Uttal et al. (2013) and Voyer et al. (1995) concluded that although training benefits all participants, it does not consistently eliminate the gender gap. These findings underscore the complexity of the gender-spatial ability relationship and the need for multifaceted interventions.

Neurological research also sheds light on gender differences in spatial tasks. MRI studies have identified that males generally have a larger surface area in the parietal lobe, associated with mental rotation tasks, while females exhibit greater gray matter volume in the same region (Frederikse et al., 1999; Koscik et al., 2009). This structural difference may partly explain performance variability. Additionally, hormonal studies indicate that prenatal androgen exposure influences spatial abilities in both sexes. Girls with higher prenatal testosterone levels due to congenital adrenal hyperplasia tend to exhibit more male-typical play behaviors and perform better on spatial tasks (Hines, 2010; Puts et al., 2008).

Another factor to consider is the evolution-based hypothesis, which argues that sex differences in spatial ability arose due to the division of labor in ancestral environments. Men, as hunters, developed advanced spatial navigation skills, while women, as gatherers and caretakers, evolved skills related to verbal fluency and object location memory (Geary, 1995). Cross-cultural studies have provided support for this theory, showing that spatial ability differences are consistent across diverse cultures, even when language and mathematical abilities vary (Lippa, 2010).

Despite biological and cultural influences, individual variability in spatial performance remains high, and not all males outperform all females. Factors such as socio-economic status, educational background, and individual interests also mediate the development of spatial ability. For example, school curriculums that emphasize spatial reasoning, such as geometry or mechanical drawing, can foster skill acquisition irrespective of gender (Battista, 1990).

Several instruments have been developed to assess spatial ability, such as the Mental Cutting Test, Vandenberg Mental Rotation Test, and Purdue Spatial Visualization Test (Guay, 1976; Shepard & Metzler, 1971). These standardized tests help identify gender disparities in specific components of spatial cognition. Research shows that males tend to excel in mental rotation and spatial perception, while females demonstrate strength in object location and memory (Halpern, 2000; Jones & Anuza, 1982).

Given the multidimensionality of spatial ability and the intricate interplay between biological, social, and experiential influences, it becomes essential to explore gender differences through empirical analysis. The present study aims to examine the gender difference in spatial ability with a particular focus on horizontal and vertical size perception. While many previous studies have confirmed the existence of male advantage in spatial tasks, fewer have focused on the subcomponents of spatial perception such as size estimation and orientation.

Understanding the nature and extent of gender differences in these subdomains can inform targeted interventions in educational and training contexts. If identified early, these differences can be addressed through gender-sensitive teaching strategies, curriculum design, and cognitive training programs. Moreover, this line of research contributes to the broader discourse on gender equity in education and cognitive development.

Thus, the current study addresses the following objectives: (1) To assess gender differences in overall spatial ability; (2) To evaluate gender differences in horizontal size perception; and (3) To evaluate gender differences in vertical size perception. Based on the literature, it is hypothesized that significant gender differences will exist in all three dimensions, with males expected to perform better, particularly in spatial perception tasks.

By examining these dimensions, the study not only contributes to existing psychological and educational knowledge but also offers practical insights for educators and policymakers aiming to bridge gender gaps in cognitive performance and STEM-related fields.

METHOD

This study aimed to investigate gender differences in spatial ability. The methodology includes a detailed description of the participants, materials used, and procedural steps followed in the research.

Participants

The study was conducted with a total of 70 students from Sree Sankaracharya University of Sanskrit, Kalady (S.S.U.S Kalady). The sample consisted of an equal number of male and female students drawn from various academic departments. Participants were selected through purposive sampling, ensuring balanced gender representation.

Materials

The following materials were used for data collection and experimentation:

Multidimensional Aptitude Battery II (MAB-II)

The MAB-II, developed by Douglas N. Jackson and published by Sigma Assessment Systems Inc., is a standardized test designed to assess intellectual abilities in individuals aged 16 and above. It consists of two major sections: Verbal and Performance. The Verbal section includes subtests on information, comprehension, arithmetic, similarities, and vocabulary. The Performance section includes digit symbol, picture completion, spatial, picture arrangement, and object assembly subtests. The full test duration is approximately 50 minutes, and it can be administered either via computer or by a trained psychologist. All items are multiple-choice and have undergone item selection procedures to ensure fairness across gender, nationality, age, and cultural groups.

For the purpose of this study, only the spatial subtest from the Performance section was used. This subtest assesses an individual's ability to mentally manipulate abstract objects within two-dimensional space.

Additional Materials

- **Stick:** A wooden stick of 110 cm length was used as a physical reference object.
- **Screens:** Two rectangular screens measuring 185 cm × 45 cm were used, one placed vertically and the other horizontally.
- **Stickers:** Adhesive stickers were used to mark the length of the stick and serve as reference points on both screens.
- **Measuring Tape:** Used to record participants' estimations and calculate deviations from the actual length.

Procedure

The study comprised two experimental tasks conducted sequentially.

Experiment 1: Spatial Aptitude Assessment

Participants were individually invited to a quiet, comfortable room for testing. The spatial aptitude subtest from the MAB-II was administered in a paper-and-pencil format. Clear instructions were given, and participants were required to complete the test within 15 minutes.

Experiment 2: Size Perception Task

Following the aptitude test, participants were escorted to a different room for the size perception task. The examiner occupied a fixed position, and participants were guided to a marked location. Initially, the stick was concealed behind the examiner. Upon the participant assuming the correct position, the examiner revealed the stick vertically for 5 seconds and asked the participant to observe it carefully. The stick was then hidden, and the participant was instructed to mark the perceived length on the vertical screen. The same procedure was repeated with the stick displayed horizontally. In half of the trials, the vertical orientation was presented first; in the remaining trials, the horizontal orientation preceded. The deviation between the actual and marked length was recorded for each participant.

RESULTS

The aim of the study was to examine gender differences in spatial ability using both a standardized paper-pencil measure (MAB-II) and a real-life size perception task. The results are presented in two sections: (1) performance on the Multidimensional Aptitude Battery-II (MAB-II), and (2) performance in real-life size perception tasks involving vertical and horizontal estimations.

Spatial Ability Test Using MAB-II

Table 1 Mean and Standard Deviation of Spatial Aptitude Scores (MAB-II) Among Male and Female Students

Gender	N	Mean score	Std. Deviation	t	Sig. (2-tailed)
Male	35	26.46	10.402	2.582	.012
Female	35	20.31	9.483		

The results indicate a statistically significant difference between male and female students in spatial aptitude scores (t = 2.582, *p* = .012). Male students (M = 26.46, SD = 10.40) scored significantly higher than female students (M = 20.31, SD = 9.48), suggesting that males performed better on the spatial component of the MAB-II.

Size Perception Task (Real-Life Experiment)
Vertical Size Perception

Table 2 Mean and Standard Deviation of Vertical Size Perception Among Male and Female Students

Gender	N	Mean score	Std. Deviation	t	Sig. (2 tailed)
Male	35	-7.228	11.682	-1.642	.105
Female	35	-2.274	13.500		

There was no statistically significant difference between male and female students in vertical size perception (*t* = -1.642, *p* = .105). However, females (M = -2.27) performed slightly better than males (M = -7.23), as their estimations were closer to the actual size of the stick (110 cm), though the difference was not statistically significant.

Horizontal Size Perception

Table 3 Mean and Standard Deviation of Horizontal Size Perception Among Male and Female Students

Gender	N	Mean score	Std. Deviation	t	Sig. (2-tailed)
Male	35	-12.857	8.093	-3.249	.002
Female	35	-3.457	15.084		

There was a statistically significant difference between male and female students in horizontal size perception (*t* = -3.249, *p* = .002). Female participants (M = -3.46, SD = 15.08) demonstrated more accurate estimations compared to males (M = -12.86, SD = 8.09), suggesting that females outperformed males in horizontal size perception.

DISCUSSION

The findings of this study reveal a complex picture of gender differences in spatial ability. On the standardized paper-pencil test (MAB-II), male students significantly outperformed female students in spatial aptitude. This aligns with earlier findings such as those by Koscik et al. (2009), who found structural differences in the parietal lobe associated with enhanced mental rotation abilities in men. Similarly, Frederikse et al. (1999) observed that males exhibited greater left inferior parietal lobule volumes and asymmetry, potentially contributing to better spatial reasoning.

However, results from the real-life size perception task show a different trend. In vertical size perception, no significant gender difference was found, although female participants were closer to the actual size. In horizontal size perception, females performed significantly better than males. This discrepancy between standardized testing and real-world spatial tasks suggests that spatial ability is multifaceted and context-dependent.

One possible explanation for this contrast lies in the nature of the tasks. The MAB-II primarily assesses spatial visualization and mental rotation, whereas real-life size perception involves spatial perception and working memory. Real-life experiences, environmental exposure, and childhood play activities could contribute to enhanced size perception in females. For instance, girls may engage more with tasks involving measurement and spatial organization during play, which may not necessarily enhance performance in abstract spatial visualization but could improve real-world spatial judgments.

Moreover, socialization and educational opportunities may influence spatial skill development. As Baenninger and Newcombe (1989) suggested, training and environmental input are essential for optimal spatial development. Boys often receive more exposure to spatially demanding tasks and toys, leading to greater practice effects in tasks like mental rotation. However, this does not necessarily translate into superior performance in all aspects of spatial ability, as demonstrated by the results of the real-life experiments.

These findings also raise questions about the validity and ecological relevance of standardized tests such as the MAB-II. While useful, paper-pencil tests may not fully capture the nuances of spatial ability as it manifests in real-world settings. The results support the inclusion of ecologically valid, task-based measures for a more comprehensive assessment of spatial ability.

In conclusion, the present study indicates that while male students may excel in abstract spatial tasks, female students may demonstrate superior real-world spatial perception. This highlights the importance of using diverse assessment methods to understand gender differences in cognitive abilities. Further research incorporating neurobiological, developmental, and sociocultural perspectives is needed to deepen our understanding of these differences.

CONCLUSION

This study explored gender-based differences in spatial ability through a combination of standardized testing and real-world perceptual tasks. The findings affirmed previous research suggesting that males generally outperform females in abstract spatial reasoning tasks, as evidenced by higher scores on the MAB-II spatial subtest. This aligns with existing literature attributing such performance differences to neuroanatomical, hormonal, and social learning factors.

However, the results also offered a compelling counterpoint: in horizontal and vertical size perception tasks that required practical spatial judgment, females performed more accurately—especially in horizontal estimation, where the difference was statistically significant. This discrepancy between standardized test performance and real-world spatial behavior highlights the contextual nature of spatial cognition and suggests that gender differences in spatial ability are not uniform across all dimensions.

The results support a biopsychosocial interpretation of spatial ability, where biological predispositions, socialization patterns, and environmental experiences intersect to shape individual performance. While males may excel in mental rotation and visualization tasks common in academic assessments, females may possess strengths in spatial estimation and perception tasks that mirror everyday experiences.

In practical terms, these findings underscore the need for diverse and inclusive assessment methods in education and research. They also suggest the value of tailored training interventions aimed at enhancing spatial competence across genders. Future studies should incorporate longitudinal designs and neurocognitive measures to further unravel the developmental and contextual factors influencing spatial ability.

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Conflict of Interest

The author(s) declared no conflict of interest.

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