A C T A U N I V E R S I T A T I S L O D Z I E N S I S
FOLIA SOCIOLOGICA 43, 2012

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THE SOCIAL RELEVANCE AND THE SOCIO-CULTURAL ORIGINS OF GENDER DIFFERENCES IN SPATIAL ABILITIES

Abstract. All over the world girls are still highly underrepresented in STEM (Science, Technology, Engineering, Mathematics) subjects in school, and only a small percentage of women choose occupational careers in that field. The socially-influenced gender differences in spatial abilities – particularly in the ability to rotate two- or three-dimensional objects in one's mind – are considered as a cognitive mediator of that gender gap. This paper gives an overview of the social causes and social consequences of the gender differences in spatial abilities. It focuses on socio-cultural influences, including gender stereotypes (e.g. the phenomenon of the "stereotype threat"), and the importance of role models in family and school. Furthermore, personal factors like the ability-related self-concept and the effects of experience and training are taken into consideration. The results of empirical studies are reported which reveal that mental-rotation performance is strongly influenced by gender-specific differences in spatial experiences, role models, the ability-related self-concept and socio-economic status. Finally, the paper discusses why and how women`s perceived lack of spatial abilities might lead to gender-typical educational and occupational choices.
Keywords: gender differences, spatial ability, occupational choices, training effects, role models, gender stereotypes.

1. Introduction

The situation of women in the European educational system has steadily improved in recent decades. Girls are more successful than boys in school, they more often graduate from high-school, they obtain better school marks, and they are equally successful as boys at colleges and universities, at least in many fields of study. Discrimination against women seems to be obsolete, at least if one considers the numbers of school and university degrees. In spite of these gains in education however, women are less successful in entering an occupational career after

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school or university, and there is still a disparate female minority in managing positions. Likewise, their academic careers are characterized by a vertical segregation: Women represent only 36% of Grade B academic staff and merely 18% of grade A academic staff (European Commission 2009).

A closer look at the subjects young women choose and the career opportunities these fields open up shows that a gender gap still exists in the field of STEM (Science, Technology, Engineering, Mathematics). Girls opt for language, literature and arts when they have to choose their major. The proportion of female students in the field of engineering at universities in Germany is only 14%, and the same trend, although not as pronounced, can be identified in other countries in the EU, e.g. the percentage in Poland is 24%, and in France 27%. The proportion of women in the fields of science, mathematics and computing is only slightly higher (35% in Germany and 37% in France). Poland, however, is one of the European countries with a relatively high percentage of females (57%), exceeded only by some other, mostly former socialist, countries like Romania, Slovenia, Cyprus and Lithuania. This situation is similar in countries beyond Europe, e.g. in the United States and Japan (European Commission 2009).

Taking into consideration the high importance of science and technology in today's societies, and the growing demand in the labor market – and thus the promising career perspectives – in the STEM fields, it is particularly important to identify possible mediators of the existing gender gap. Gender differences in spatial abilities are considered as one of the substantial agents in the choice of STEM professions and achievements and success in these fields (e.g. Smith 1964; Burnett, Lane & Dratt 1979; Barke 1993; Norman 1994; Sorby, Leopold &Górska 1999; Else-Quest, Hyde & Linn 2010). The following sections of this article discuss when and how these differences emerge, which underlying social and individual causes can be identified, and how children's spatial performance can be improved.

2. The construct of spatial ability and related gender differences

Spatial ability is an umbrella term for different ways of processing visual-spatial, non-verbal stimuli, defined as "the ability to generate, retain, retrieve and transform well-structured visual images" (Lohman 1994a: 1000). The most common classification of spatial cognitive sub-processes is that made by Linn and Petersen (1985), who divided spatial abilities into three subcategories: "spatial perception", "spatial visualization" and "mental rotation." According to them, "spatial perception" refers to the ability to orientate horizontally and vertically despite distracting information; "spatial visualization" is the ability to manufacture and manipulate spatial information; and "mental rotation" describes the fast and accurate rotation of two- or three-dimensional objects in the mind, measured e.g. by the mental-rotation tasks developed by Shepard and Metzler (1971) or with the Mental Rotations Test by Vandenberg and Kuse (1978).

These abilities are important for everyday tasks, e.g. the orientation and navigation in the environment, or parking a car (Quaiser-Pohl & Jordan 2007), but they are also a good predictor of school achievement in STEM subjects, i.e. mathematics (Fennema & Sherman 1977) and important for several academic and occupational careers such as architecture, engineering, and especially computer science (e.g.Quaiser-Pohl & Lehmann 2002; Sander, Quaiser-Pohl & Stigler 2010), i.e. mainly for those academic programmes in which the largest sex segregation can be observed (e.g. Meinholdt & Murray 1999; Vetter & Babco 1986; White 1985). In a longitudinal study with 563 intellectually talented boys and girls over 20 years of age, Shea, Lubinski and Benbow (2001) found that a higher spatial ability is likely to be found in persons who work in STEM fields, and that spatial ability uniquely predicts STEM achievement and attainment. Those girls and boys who graduated in STEM or ended up in a STEM profession after 20 years had achieved a significantly higher performance in terms of spatial ability already at the age of 13. The results of another longitudinal study, using a nationally representative sample of approximately 400,000 9^{th} to 12^{th} grade students (Wai, Lubinski & Benbow 2009) showed the same tendency. These findings reveal the importance of spatial abilities for the STEM field and suggest that inter-individual differences in spatial abilities should be more closely examined in order to reduce the above mentioned gender gap in STEM domains.

The largest and most pervasive gender differences are found in the ability of mental rotation. Gender differences favoring male adults have been reported since the 1970s (e.g. Maccoby & Jacklin 1974; Linn & Petersen 1985; Voyer, Voyer & Bryden 1995; Halpern 1992), but these differences were analysed in adults. The question at what age these differences begin is still discussed and controversial. In some studies, three- and four-month-old infants showed differences in mental-rotation tasks (e.g. Quinn & Liben 2008), which suggests that a gender difference in mental rotation emerges already in early childhood. Several other researchers report a gender difference favouring male participants in pre-schoolers (e.g. Levine, Huttenlocher, Taylor & Langrock1999; Hahn, Jansen & Heil 2010). However, these findings suggesting an early emergence of male advantage in mental rotation should not be interpreted as undisputable proof that gender differences in mental rotation are due to biological causes only. The socialization process starts early and the influence of socio-psychological and experiential variables on spatial performance has been demonstrated in several studies and on many levels (e.g. Neuburger, Jansen, Heil & Quaiser-Pohl 2011;Sander, Quaiser-Pohl & Stigler 2010; Quinn & Liben 2008).

Neuburger et al. (2011), for example, examined the mental-rotation performance of 432 elementary-school children by using three different mental-rotation tasks similar to those in the "Mental Rotations Test" (MRT, Vandenberg & Kuse 1978). One half of the participantswere second graders, and the other half were fourth graders. The results showed gender differences in fourth graders, but not in second graders, which supports current studies indicating that gender differences can be reliably found from ten years onwards (Titze, Jansen &Heil 2010a). This is not in line with the assumption that the male advantage emerges as early as mental rotations can be performed, as Linn and Peters (1985) assumed, and it contradicts purely biological arguments in this area. Although there is some evidence in favor of genetic and hormonal influences on the gender difference in mental rotation (e.g. Pezaris & Casey 1991; Grimshaw, Sitarenios&Finegan, 1995), the influence of socio-psychological and experiential variables on spatial abilities and their malleability (Uttal et al. 2012) cannot be dismissed, and is therefore more closely investigated below.

3. Socio-cultural factors influencing spatial abilities

Both cross-cultural differences in spatial abilities in general and gender differences in spatial performance respectively (Berry 1966; Munroe & Munroe 1971) point especially to the role of socio-cultural factors in this area and have brought into focus the importance of everyday activities and socio-cultural practices for spatial skills (Gauvain 1993).

In addition, the fact that the direction of the gender differences varies across different cultures is an argument against purely biological theories of spatial differences between sexes. Hoffman, Gneezy and List (2011) identified the role of nurture by a comparison of 1279 inhabitants of patrilineal and matrilineal villages in Northeast India. Participants had to solve a puzzle within 30 seconds. Men outperformed women in the patrilineal societies, but not in the matrilineal societies.

Besides the social system itself, differences within educational systems seem to influence the development of spatial abilities. In contrast to Germany, the social system in Cambodia is organized hierarchically and there are many other differences in social life and education, e.g. huge differences in math curricula (Janssen & Geiser 2012). Janssen and Geiser investigated mental-rotation performance in both nations and found that the performance in favor of the Germans could be partly explained by fundamental differences in dealing with spatial problems in math classes, and consequently by differences in the solution strategies used. The Cambodians used analytic strategies more often than the usually more successful holistic strategies in the Mental Rotations Tests.

These findings are in line with a cross-cultural study by Lippa, Collaer and Peters (2010), who found differences in both the MRT and a line-angle judgment test between Western and Eastern samples. Men's performance exceeded women's performance in 53 nations, and Western nations generally outperformed Eastern nations (e.g. Malaysia, India, Thailand), but participants from those Asian nations with a higher economic development and more demanding educational systems (e.g. China and Japan) on average performed as well as participants from Western nations. Gender differences, however, tended to be larger in the economically advanced nations.

Differences in spatial abilities can also be found within one nation due to profound socio-structural changes within different parts of society. Sander et al. (2010) compared students majoring in computer visualization (CV) and in non-technical fields (NTF; e.g. education, humanities and social sciences) from a University in West Germany (former FDR) with students from a University in East Germany (former GDR). CV students outperformed students majoring in NTF; East German students achieved significantly higher MRT scores than West German students; and the female students majoring in computer visualization obtained higher scores than the female students in non-technical fields. The reasons for these interesting findings can be seen in differences in socialization: CV students showed a higher ability-related self-concept for STEM and reported more technical and computer experience, and West German students expressed more traditional gender-role attitudes than the students from East Germany. The advantage of the latter might reflect the poly-technical education they had in their early school years, and the explicit focus on technical topics.

As the studies show, the development of spatial abilities in men and women and the emergence of gender differences are affected by a large variety of factors. Like performance in other areas, spatial performance depends on the ability-related self-concept, on gender stereotypes, and on experiences, which are partly influenced by social background. The impact of "role models" on these factors is examined in more detail in the following section, based on a story-telling experiment we conducted with German fourth graders.

3.1. The influence of role models on gender stereotypes, spatial performance, and the spatial self-concept

According to the social-cognitive theory of gender development (Bussey & Bandura 1999), gender stereotypes are established by three mechanisms: modeling, an active experience followed by evaluative reactions, and direct intuition. Modeling processes can occur in face-to face contacts with significant social agents in the individual's real-world environment, or by the presentation of gender roles in the media. Bussey and Bandura (1999) consider media representations of gender roles as influential sources of gender schemata, stating that „children are continually exposed to models of gender-linked behaviors in readers, storybooks, video games, and […] television" (Bussey & Bandura 1999: 701).

Data from media psychology show a positive relationship between exposure to gender-stereotyped media, on the one hand, and sex-typed behavior and sex-role stereotyped attitudes on the other (Oppliger 2007). Role models in the positive sense are "individuals who provide an example of the kind of success that one may achieve, and often also provide patterns of the behaviors that are needed to achieve such success" (Lockwood 2006: 36). There are several mechanisms by which role models can positively influence performance, e.g. reduction of extra-task thinking (McIntyre, Paulsen, Taylor, Morin & Lord 2011), enhancement of self-evaluations and motivation (e.g. Blanton, Crocker, & Miller 2000; Marx & Roman 2002), and inspiration and guidance with respect to academic aspirations (Lockwood & Kunda 1997).

The impact of gender-role narratives on children's gender stereotypes has been reported e.g. by Ashby and Wittmayer (1978), who demonstrated an increase in fourth graders' appropriateness ratings of traditionally male jobs and characteristics for females following their exposure to stories depicting women in nontraditional roles. Similarly, Scott and Feldman-Summers (1979) found that exposure to female story protagonists engaging in nontraditional activities influenced children's sex role perceptions: Male and female third and fourth graders who had read more stories with a counter-stereotypical female protagonist than stories with a stereotypical male protagonist considered it more likely that girls could do what the protagonist did. Concerning the impact of role models on performance, several studies have shown that role models who are members of an individual's stereotyped group can prevent stereotype threat: Females' math performance has been found to be protected against stereotype threat by a female experimenter with a perceived high math competence, even without the physical presence of this experimenter (Marx & Roman 2002). Similarly, 11–13 year-old school girls were found to perform better in a math test when positive same-gender role models were accessible (Huguet & Régner 2007), while women who had viewed gender-stereotypical television commercials underperformed in a math test, avoided math tasks, and showed less interest in educational/vocational options related to quantitative domains (Davies, Spencer, Quinn & Gerhardstein 2002). In contrast to the mathematic domain, the effects of *spatially* skilled role models have not yet been examined.

3.1.1. Acceptance and effects of spatially-skilled role models in fourth graders – a story-telling experiment

We therefore investigated role-modeling processes in response to the presentation of male and (stereotype-inconsistent) female story protagonists, whose features could be deliberately designed and controlled, with 329 fourth graders from 13 German public schools. The effects of a fictional role model displaying good spatial skills (e.g. understanding maps, solving geometric tasks, drafting and constructing buildings) on girls' and boys' gender stereotypes, spatial performance, spatial self-concept, and self-esteem were assessed. Furthermore, the degree to which boys and girls accept, i.e. positively value, male and female spatially-skilled models and perceive them as typical for their own gender was explored, because these two variables are supposedly important prerequisites for subsequent attitude changes (Bandura 1974; Wilder 1984).The design of the study included three groups: the experimental group, in which a female role model was presented in four stories; a first control group, in which a male role model was presented in four stories; and a second control group, in which four gender-neutral texts were presented, without role models. In the female role-model (experimental) group and the male role-model (first control) group, model acceptance and perceived gender typicality were assessed during an intervention after each of the four stories.

In contrast to our hypotheses, no gender-specific effects of the male and female fictional role models on gender stereotypes, self-concept, and mental-rotation performance were found. However, a group-independent decrease in girls' stereotype scores from pre- to post-test, and an increase in their spatial performance were found, probably because of their repeated interaction with a competent female experimenter, who served as a real-world, face-to-face model of spatial abilities by administering the scientific spatial tests. Although the positive impact of fictional same-sex models in the spatial domain could not be confirmed, model acceptance and gender typicality ratings indicated that female fourth graders accept spatially-skilled fictional models and, despite their stereotype-inconsistent spatial skills, do not perceive them as "unfeminine". Further research should explore how these modeling prerequisites of spatially-skilled female models can be effectively used to reduce the gender gap in the spatial domain, e.g. by examining how content (fiction vs. facts) and type of presentation (e.g. written/read stories vs. television) influence the impact of story interventions in the spatial domain. The present findings suggest that such interventions should be enriched by offering opportunities for girls to make new spatial experiences on their own, optimally in a scenario guided by inspiring female mentors who display high, but attainable, spatial skills, thus enabling each girl to tell her own spatial-adventure story.

Besides the effects of the storytelling intervention, some other interesting aspects of the present findings deserve attention. First, the existence of a spatial gender stereotype was confirmed for boys and partially confirmed for girls. Both sexes agreed that building and construction activities are more typical for boys than for girls. As girls did not show a male stereotype for other spatial activities and abilities (mental rotation, spatial orientation, line reflection), further stereotype research in this area should encompass a differentiated perspective on the specific subcomponents of the umbrella construct "spatial ability". In contrast to the findings with adult females (Hausmann, Schoofs, Rosenthal & Jordan 2009), no gender stereotype was found for mental rotation with girls; but as the cube figures of the MRT, the most commonly used mental-rotation task, resemble building blocks, this test nevertheless might activate a male stereotype (see Neuburger, Heuser, Jansen & Quaiser-Pohl 2012).

3.2 Influence of socio-economic and educational background on spatial performance

Another important observation is that gender differences in spatial abilities are also modified by socio-economic status (SES) and educational background. Levine, Huttenlocher, Taylor and Langrock (2005) investigated the spatial performance of 547 students from differing socio-economic backgrounds. Interestingly, the achievement of boys and girls did not differ in the low-SES groups, while boys outperformed girls in the middle- and high-SES groups, which accomplished better overall results than the low-SES groups.

3.2.1. The relationship between the socio-economic background, mental-rotation performance, gender stereotypes, and the spatial self-concept

Embedded in the role-model experiment mentioned above, associations between socio-economic status (SES) on the one hand, and mental-rotation performance, gender stereotypes, and spatial self-concept on the other hand, were examined. The parents of 110 fourth-grade girls and 109 fourth-grade boys (average age: ten years) filled in a SES questionnaire, in which they were asked to indicate their school-leaving certificate and professional degree. Following Jöckel et al. (1998), rank-ordered values reflecting the „Index of Educational Level" (IEL) were assigned to the different combinations of school and professional graduation levels. Mental-rotation performance of their children was assessed by administering a shortened paper-pencil version of the MRT in schools (Titze, Jansen & Heil 2010b). Furthermore, the children's spatial self-concept and gender stereotypes were assessed by administering two age-appropriate questionnaires. Data analyses showed significant, gender-specific associations between SES, operationalized by parental IEL, and children's answers in the tests and questionnaires. For boys, mental-rotation performance was significantly correlated with maternal IEL and marginally significantly correlated with paternal IEL in a positive direction, i.e. higher IEL values were associated with better mental-rotation performance; while neither boys' gender stereotypes nor boys' spatial self-concept were correlated with parental IEL. For girls, mental-rotation performance was marginally significantly correlated in the positive direction with the combined parental IEL, which reflects the IEL of the parent with the higher educational level. Additionally, in contrast to boys' correlational pattern, there was a significant negative correlation between girls' maternal IEL and girls' general gender stereotypes, and a significant negative correlation between girls' paternal IEL and girls' spatial self-concept. Thus, a higher maternal IEL was associated with less stereotypical answers of girls in the gender-stereotype questionnaire and, astonishingly, a higher paternal IEL was associated with a lower spatial self-concept in girls. In group comparisons using a median-split technique, it was found that girls' mental-rotation performance was more strongly associated with the paternal IEL than with maternal IEL. On average, girls with a high paternal IEL solved one test item more than girls with a low paternal IEL (this difference was statistically significant); the difference between girls with a high maternal IEL and girls with a low maternal IEL was also significant, but smaller. For boys, no significant performance difference between high and low paternal/maternal IEL groups was found.

Because of the cross-sectional design of the study, these associations cannot be unambiguously interpreted in a causal way. However, in line with prior research, they suggest that spatial abilities, activities, and gender beliefs are intertwined with the parental educational level, i.e. socio-economic status, in children. In line with the results of Levine et al. (2005),the gender differences in the middle- and high-SES groups and the gap between upper- and lower-SES groups can be explained in various ways: One reason might be differences in the quantity and kinds of activities that are important for the development of spatial abilities. Independent from the SES, boys more willingly participate in male-stereotyped activities related to spatial skills, like playing video games, Lego, or constructing things, than girls (see e.g. Neuburger, Ruthsatz, Jansen, Heil, & Quaiser-Pohl in preparation).Since the access to more expensive toys promoting spatial abilities might be denied for both male and female children from low-SES groups, low-SES boys might show no performance advantage in contrast to upper-SES boys. Furthermore, the freedom to explore one's neighborhood has been found to boost spatial abilities (e.g. Matthews 1987). As both boys and girls from lower-SES groups, and also girls from upper-SES groups, are likely to spend less time exploring their neighborhood than boys from upper-SES classes (because of their parents fears of danger to them in the neighborhood) (e.g. O'Neil, Parke & McDowell 2001), differences in exploring experiences probably also contribute to the interactive effects of gender and SES on spatial-ability.

3.3. Effects of experience and training on spatial abilities and their social mediation

In the preceding sections, it has been shown that spatial abilities undergo developmental processes and show considerable individual differences, depending on experiences, SES, gender stereotypes, and the ability-related self-concept. Furthermore, it has been indicated that spatial abilities are not fixed, but malleable.

One effective tool to improve children's spatial abilities is to use spatial language. Use of spatial language (e.g. *outside*, *under*, *over*) helps infants to form more perceptually diverse spatial categories and to perform better in **spatial** problem-solving tasks at a later age (Newcombe 2010; Casasola 2008; Pruden, **Levine**, Huttenlocher 2011). In addition to the use of spatial language, several other spatial activities such as specific training programmes, spatial tasks, and video games can encourage spatial performance.

The durable and transferable effects of trainings in spatial thinking on performance in all subcategories of spatial abilities have been demonstrated by the results of a meta-analysis including 217 research studies conducted in the US, several European countries (e.g. Germany and Spain), Canada, Australia and some Asian nations (e.g. Korea) by Uttal et al. (2012). The meta-analysis of these research studies revealed that the durability and the transferability of training effects are independent from the type of training, i.e. regardless of the training format (course programme, video game or spatial-task training), each programme appears to produce an increase in spatial abilities. However,the results of training studies with respect to training effectiveness depend on several moderators, particularly the inclusion of control groups and their filler-task content, as well as the study design. Another important moderator was the initial level of performance: Low-scorers improved more visibly after training, i.e. the degree of malleability is affected by the initial level of spatial abilities (e.g. Terlecki, Newcombe & Little 2008). Interestingly, the level of improvement is not affected by participants' characteristics, including sex and age.[1] Spatial performance can be improved across one's entire life span and both men and women benefit from spatial trainings (Uttal et al. 2012), but it must be noted that there is a difference in the temporal course of participants' response to training. Terlecki, Newcombe and Little (2008), for example, investigated the effects of mental-rotation training with nearly 1300 undergraduates and found differences in men's and women's growth trajectories. Men showed rapid gains, while especially women with lower levels of spatial experience did not improve until after a few weeks of training. For women and participants with initially low experience in general, there seems to be a threshold that needs to be reached before profiting from training (see also Newcombe & Frick 2010; Uttal et al. 2012). This is in line with earlier findings by Baenninger and Newcombe (1989), who confirmed that females benefit equally from long and exhaustive training.

[1] Uttal et al. (2012, p. 15): "The large standard error in turn reduces the likelihood of finding a significant result when comparing age effects. Thus, our analyses highlight the need for further research involving systematic within-study comparisons of individuals of different ages. Although our analyses clearly suggest that spatial skills are malleable across the life span, such designs would provide a more rigorous test of whether spatial skills are more malleable during certain periods."

3.3.1. The influence of technical experience and technical training on mental-rotation performance, gender stereotypes, and the spatial self-concept

In a field experiment, 79 German children between eight and fourteen years of age who participated in one of three extracurricular technology courses were examined before and after the respective course (Schmidt 2011). The following three courses were included in the study: (1) the “Game Camp”, in which participants learned to program a computer game; (2) the “Cartoon Camp”, in which participants designed animated film clips; and (3) the “Robotics Camp”, in which participants programmed LEGO® Mindstorm NXT robots. Two girls and 30 boys participatedin the “Game Camp”, 11 girls and 20 boys in the “Cartoon Camp”, and only boys (n = 16) in the “Robotics Camp”. Before and after the courses, mental-rotation performance, spatial self-concept, and gender stereotypes were assessed. Results showed that the pre/post changes in the assessed variables depended on the course attended: Participants of the “Game Camp” showed a trend towards a higher spatial self-concept after the course and a significant reduction of their general, i.e. non-spatial, gender stereotypes; participants of the “Cartoon Camp” showed a significant reduction of their spatial gender stereotypes; and participants of the “Robotics Camp” showed a significant improvement of their mental-rotation performance, a significant *increase* of their spatial gender stereotypes, and a trend towards *higher* general gender stereotypes after the course. Presumably, these disparate patterns of changes in the participants of the three courses were, on the one hand, due to differences in the content of the courses, i.e. to the specific topics and technical methods covered in each course; but on the other hand these results also reflected the different proportions of female participants in the camps, particularly the fact that all participants of the “Robotics Camp” (the only course after which mental-rotation performance improved!) were male. Overall, the results of this exploratory field study suggest that specific kinds of technological experience and learning can improve spatial-test performance in children, and that technology courses with mixed-gender groups can reduce gender stereotypes, while technology courses with only male participants are likely to increase gender stereotypes. The challenge implied in these findings is to conceive strategies for motivating girls to participate in technology courses, especially in those courses that have the potential to close the gender gap in spatial abilities.

4. Conclusions

In this paper, it has been shown that there are manifold reasons for gender differences in spatial abilities. However, opportunities for practice are omnipresent, and spatial abilities are far from being explained and determined solely by biological-genetic factors. As outlined in the first two sections of this article, the gender gap in children's and adults' spatial performance is strongly associated with the gender gap in academic and professional STEM fields. Therefore, interventions aimed at promoting girls' and women's spatial abilities provide a promising approach for closing the gender gap in STEM. As Uttal et al. (2012) state, it might not even be necessary for women to achieve the same level of spatial performance as men in order to succeed in STEM domains, because a certain threshold level of spatial ability, which can be achieved by deliberate training and spatial experience, is sufficient for a STEM career. Reaching this threshold level might also enhance females' ability-related self-concept, which usually is in discrepancy with the ability itself, especially in male-stereotyped ability domains like spatial abilities and the STEM field (Quaiser-Pohl 2012). The research described above suggests that much of the female potential in spatial abilities, and thus in STEM, still lies idle because of spatial gender stereotypes and gender differences in spatial self-concept, which exist already in elementary school children. These "psychological barriers" restrict girls' and women's educational and occupational choices by impairing spatial-ability development and performance, and thus constitute a challenge for society, i.e. for scientists, educators, parents – and finally for women themselves.

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SPOŁECZNE ZNACZENIE I SPOŁECZNO-KULTUROWE POCHODZENIE RÓŻNIC DOTYCZĄCYCH ZDOLNOŚCI PRZESTRZENNYCH KOBIET I MĘŻCZYZN

Streszczenie. Artykuł dotyczy problemu niedoreprezentacji kobiet w obszarach nauk ścisłych, technologii, inżynierii i matematyki, a w konsekwencji niewielkiego odsetka kobiet wybierającego karierę zawodową w tych wspomnianych obszarach. W tekście skoncentrowano się na wpływie społeczno-kulturowych stereotypów, zwłaszcza tych dotyczących płci społeczno-kulturowych (*gender stereotypes*) na modelowanie ról społecznych w rodzinie i szkole. Zaprezentowane zostały również wyniki badań obrazujące zależność między zdolnościami przestrzennymi a zróżnicowaniem ze względu na płeć społeczno-kulturową w zakresie doświadczeń przestrzennych, modeli ról społecznych, samooceny własnych zdolności i statusu społeczno-ekonomicznego.

Słowa klucze: różnice płci, role społeczne, wybór zawodu, stereotypy społeczno-kulturowe.