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Effects of Childhood Activities on Spatial Skills

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Abstract

This study investigated the association between childhood activities and later spatial abilities. Additionally, the impact of sex and hometown was tested. Undergraduate students completed a demographics question asking about their hometown, along with the Santa Barbara Sense of Direction (SBSOD; Hegarty et al., 2002) questionnaire, the Card Rotation Test (CRT; Ekstrom et al., 1979), the newly revised version of the SAQ, the Southern California Spatial Activities Questionnaire (SoCalSAQ; Munns et al., 2022), the Paper Folding Test (PFT; Ekstrom et al., 1976), and the Childhood Wayfinding Experience (CWE; Lawton & Kallai, 2002)) questionnaire. The results indicated a non-significant association between childhood activities and later spatial abilities. The findings also suggest an association between 2D mental rotation and spatial visualization abilities. Participation in creative and artistic activities may be associated with an individual's 2D mental rotation abilities. A person's involvement in navigation-related activities may also be related to childhood wayfinding experiences and spatial visualization abilities. Future research should use the newly revised SoCalSAQ with larger samples to better understand the relationship between childhood activities and later spatial abilities.

Keywords: spatial abilities, childhood activities, SoCalSAQ, childhood wayfinding experience, spatial visualization abilities, mental rotation

Effects of Childhood Activities on Spatial Skills

Spatial skills are defined as the ability to understand and create visual representations and connections about the locations of items within the environment (American Psychology Association, 2022). These skills assist not only in everyday lives when interacting with the environment but also in specific fields and subjects related to science, technology, engineering, and mathematics (STEM; Munns et al., 2022). Spatial skills consist of both small-scale and large-scale spatial abilities. Small-scale spatial skills are usually identified as the ability to transform and turn a small object by visualizing it in the mind (Munns et al., 2022). For example, an artist visualizing an orange being rotated while they are drawing it. Munns et al. (2022) performed a review and found that a great deal of research has been done on small-scale spatial skills and their impact, specifically on STEM abilities. Large-scale spatial abilities, on the other hand, relate to the individual's capacity to navigate through a space (Munns et al., 2022). Munns et al. (2022) mention examples of activities that utilize large-scale spatial skills; these include sports, navigating a large area, and some virtual activities like exploring a virtual environment in a video game. As noted again by Munns et al. (2022), not as much research has been done on these large-scale spatial skills.

Previous research suggests that activities that children participate in may influence the development of later spatial abilities and STEM skills in adulthood (e.g., Moe et al., 2018; Vieites et al., 2020; Doyle et al., 2012; Jansen et al., 2018; Munns et al., 2022). For instance, Moe et al. (2018) found that the toys children choose to play with when they are young can predict their later spatial abilities and their involvement in STEM fields. Specifically, playing with toys with a spatial component, like blocks, was associated with better performance on mental rotation tests and an increased likelihood of involvement in STEM fields later in life. In

addition, a study done by Polinsky et al. (2021) investigated the connection between spatial ability and digital games in young children. The researchers found that the pattern shown with spatially related toys and spatial abilities is also seen with digital games that young people play. This means that both digitalized spatial-related toys, like video games and non-digitalized spatial-related toys, such as blocks, are associated with spatial skill improvement and, in turn, STEM skill improvement. In other research, Jansen et al. (2018) evaluated the impact of physical education programs in schools on students' spatial abilities. They found that subjects that participated in school-organized physical education activities performed better on mental rotation tests, which they later identified as positively impacting success in science and math. The authors discuss how this could be because better motor expertise could improve mental rotation speed. As a study done by Tian et al. (2022) notes, since spatial abilities have shown to be a significant predictor of involvement in STEM fields, it is an important factor to look at when trying to encourage and understand why there are not as many females in STEM fields. Research in this field may benefit educators and parents as they can ensure that they implement the proper interventions to give all genders an equal chance to pursue a career in the STEM field (Tian et al., 2022).

The connection between spatial skills and STEM education, evident in the literature (e.g., Moe et al., 2018; Jansen et al., 2018), furthers the interest in how childhood spatial experiences may impact adult spatial skills (e.g. Vieites et al., 2020; Peterson et al., 2020; Schug et al., 2022; Doyle et al., 2012). Vieites et al. (2020) assessed how the wayfinding experiences participants have when they are younger affect their spatial experiences as they age. The study included 159 undergraduate students in the U.S. Participants were given the following questionnaires to complete: The Childhood Wayfinding Experience Questionnaire (Lawton & Kallai, 2002),

Wayfinding Strategies Questionnaire (Lawton, 1996; Lawton & Kallai, 2002), Wayfinding Anxiety Questionnaire (Lawton & Kallai, 2002), and the State-Trait Anxiety Inventory (Spielberger, 1989). The results showed that those who explored greater distances of their environment when they were younger, as indicated by their Childhood Wayfinding Experience scores, tended to use the route information less when they were adults. Vieites et al. (2020) explains these findings by stating that it makes sense that the more wayfinding an individual experiences as a child, the more independent and less reliant on inefficient wayfinding strategies, such as route information, the individual would be when navigating as adults. Additionally, this paper analyzed wayfinding anxiety. Previous research suggests no correlation between wayfinding anxiety in adulthood and the distance they were allowed to explore independently as a child (Schug, 2016). However, Vieites et al. (2020) found that the participants that reported having explored more considerable distances of their environment when they were young experienced less wayfinding anxiety, as seen in lower Wayfinding Anxiety scores when they were older.

As previously seen, there have been mixed results when looking at how a participant's environment impacts their future wayfinding anxiety (Schug, 2016; Vieites et al.,2020). Whether one's environment impacts spatial skills and strategies needs to be researched. A study done by Peterson et al. (2020) looked further at the effects that childhood spatial abilities and training have on the individual in the future. This study consisted of 346 high school students in Northern Virginia. The students were first asked to complete the preliminary SAT test and a few questionnaires, inventories, and spatial ability tests. The study focused more on spatial activities' influence on spatial strategies as opposed to spatial skills. The researchers defined spatial strategies, or spatial habits of the mind, as ways to incorporate spatial thinking when problem-

solving. Spatial skills, on the other hand, the researchers note, are the individual's ability to succeed in spatial tasks. The results indicate that childhood spatial activities significantly predicted spatial strategies. Therefore, the more the individual participated in spatial activities in childhood, the more they tended to think about problems in a spatial way. On the other hand, adolescent spatial activities were not significant predictors of spatial habits.

To add to spatial strategy literature, researchers have studied the impact of different locations and environments on spatial strategies. A study done by Schug et al. (2022) works to add more clarity to this topic while also providing data from a new population from the Faroe Islands and the United States. Schug et al. (2022) asked participants to complete the Vandenberg Kuse Mental Rotation test (Vandenberg & Kuse, 1978), modified by Peters et al. (1995). Additionally, participants were asked to identify how often they played with Lego as a child, a question based on Peters et al. (1995). Participants were also asked to complete questionnaires that reported experiences with wayfinding when the participant was young and different strategies that the participants utilized when in situations requiring the activation of spatial abilities. The results showed that people with more extensive ranges in childhood exploration relied less on route strategies. This finding supports Vieites et al. (2020) previously mentioned finding. The correlation between childhood exploration distance and route strategies, identified by Schug et al. (2022), indicated that the experiences with large-scale spatial skills that a participant has in childhood could impact the spatial strategies that the participant utilizes in adulthood. Additionally, when evaluating the effect of small-scale spatial activities, the researchers found that the more the participant played with Lego when they were younger, the more they relied on the orientation style of navigation in adulthood. Similarly to the previous finding, this result indicated that participation in small-scale spatial activities when young could

also influence spatial strategies in adulthood. The study completed by Schug et al. (2022) found that some of these results differed based on the group of participants, whether they were from the Faroe Islands or the United States. For example, the last finding stating that small-scale spatial skills influenced the later spatial strategies used was more prominent in the American participants. The fact that differences in findings are evident based on location implies that further exploration of these topics needs to be done in more locations to gain a more accurate understanding.

Some studies previously mentioned that explored the association between childhood activities and later spatial abilities have found sex differences in activities. Many of these studies have proposed that these sex differences in childhood may lead to the differences in spatial ability seen in adults (e.g., Vieites et al., 2020; Doyle et al., 2012). For example, the study by Vieites et al. (2020) on childhood experiences and adult wayfinding found that male participants were generally given more freedom to explore outside when they were young than female participants. More childhood freedom was associated with greater wayfinding comfort and the development of powerful spatial strategies for wayfinding (e.g., forming mental maps) as an adult. Doyle et al. (2012) examined how children's activities impacted spatial abilities as the subjects got older. The researchers found that the more a child was involved in activities with a spatial component, like map reading and sports, the stronger their spatial abilities were as adults. Furthermore, men tended to have participated in activities that had a spatial component more than women did. Doyle et al. (2012) proposed that these activities impacted the participants' scores on spatial tests such as mental rotation.

Further exploration of sex differences and the impact of stereotypes needs to be explored as it relates to spatial abilities. A study by Tarampi et al. (2016). This study consisted of three

different experiments. In the first experiment, the participants were divided into two groups. Both groups were asked to complete a few different perspective-taking tests, but each group was given instructions with a different emphasis. The first group, which the researchers labelled the spatial condition, was asked to complete the perspective-taking test that was not modified. They were told that perspective-taking skills were related to cognitive abilities and that males tend to perform better. The second group, which the researchers called the social condition, was asked to complete a modified perspective-taking test that included images of humans. These subjects were then told that these skills were emotional in nature and that females tended to have better scores. The results indicate that when the tests were framed from a social perspective and human figures were implemented into the tests, the sex differences in the perspective-taking scores were eliminated. The following experiments tried to isolate why these sex differences existed. The researchers indicate at the end of their study that, based on the experiments, the sex differences may result from stereotype threats. Tarampi et al. (2016) discuss stereotype threats as occurring when an individual is at risk of following a common assumption about a group they identify with. Due to these stereotype reminders, the researchers believe that when the female subjects of their study were told that the tests they were completing had something to do with emotional abilities, the sex differences were eliminated. In comparison, when the female participants were told that the tests were based on cognitive skills, which may often not be associated with female ability, the sex differences occurred.

In order to study childhood activities retrospectively, researchers use questionnaires administered to adults. Recently, Munns et al. (2022) critically examined the most common test of childhood activities, the Spatial Abilities Questionnaire- short version (SAQ; Newcombe et al., 1983; Signorella et al., 1986). The SAQ asks participants to rate their frequency of

involvement in various activities such as gymnastics, crocheting, and dodgeball using a 6-point Likert scale. Munns et al. (2022) pointed out that the SAQ activity options had not been updated since it was published in 1983 and were now very outdated. Some outdated activity options included disco dancing or making and fixing radios. As a result, Munns et al. (2022) updated the activity options, edited some of the wording on the questionnaire to make it more specific and easier for participants to complete, and added more large-scale spatial activities, as the original test did not provide these. They called their new edited version of the questionnaire the SoCalSAQ. They then tested their questionnaire to ensure its validity and found that scores in different categories were correlated with performance on spatial ability tests. For example, the grouping of navigational skills, including activities such as camping and hiking, correlated with the Santa Barbara Sense of Direction Scale and the Childhood Wayfinding Experience Scale. Further, the authors noted that activity popularity could differ in different regions and that the study should be replicated. Overall, the SoCalSAQ acts as an updated way to measure childhood activities and how spatial skills relate to them.

In the current study, the SoCalSAQ (Munns et al., 2022), the Card Rotation Test (Ekstrom et al., 1979) and the Paper Folding Test (Ekstrom et al., 1976) were administered along with questionnaires including the Santa Barbara Sense of Direction (Hegarty et al., 2002), and the Childhood Wayfinding Experience (Lawton & Kallai, 2002). These assessments were given to a sample of female participants at Brescia University College using Qualtrics. The three questionnaires were used to identify participants' activity involvement and frequency, their past wayfinding experiences, and their self-reported ability to navigate. The two tests evaluated the participants' mental rotation and spatial visualization abilities. Participants were also asked to identify where in the world they spent most of their childhood to determine how the environment

they grew up in influenced the activities they participate in and, in turn, their spatial abilities. These assessments were also used to investigate whether our population had differences in activity participation compared to the population that Munns et al. (2022) tested. In addition, if there are similar patterns of childhood activities, as assessed by the Childhood Wayfinding Experience (Lawton & Kallai, 2002) questionnaire, and the SoCalSAQ (Munns et al., 2022) and adult spatial abilities as measured by the Paper Folding Test (Ekstrom et al., 1976), Card Rotation Test (Ekstrom et al., 1979), and the Santa Barbara Sense of Direction (Hegarty et al., 2002) within women as seen in mixed-sex samples, it would suggest that adult ability differences are indeed due more to childhood activities than sex. On the other hand, if we see no such patterns within our sample of women, it suggests either that there are strong biological sex differences or that the patterns seen in previous studies are driven by men only. As an additional exploratory hypothesis, we gathered information on where participants grew up to determine whether there was a relationship between the population density of the area and later activity involvement and spatial abilities. The central hypothesis was that childhood activities identified as having a spatial cognition component measured in the CWE (Lawton & Kallai, 2002) and SoCalSAQ (Munns et al., 2022) would positively impact the participants' spatial abilities in adulthood as measured by the SBSOD (Hegarty et al., 2002), PFT (Ekstrom et al., 1976), and CRT (Ekstrom et al., 1979) even in a sample of all women.

Methods

Participants

An a priori power analysis was conducted through G*Power (Faul et al., 2007). This analysis indicated that in order to achieve a power of .80 in a 3-predictor multiple linear regression design, 77 participants were needed. Overall, there were 73 participants, with 2 being invalid due

to a lack of answers and or technical error, making the final number of participants 71. Due to technical errors and the subject's participation, some tests were not completed fully. The results section will indicate the number of participants who completed each test.

Materials

Santa Barbara Sense of Direction (SBSOD; Hegarty et al., 2002)

The SBSOD tested the participants' self-reported sense of direction. This test consisted of 15 questions and was evaluated on a 7-point Likert scale, with one being strongly disagree and seven being strongly agree. There was reversed scoring on the questions that were worded negatively. The participants who reported a better sense of direction had higher scores.

Card Rotation Test (CRT; Ekstrom et al., 1979)

This test looked at the subject's ability to rotate 2D objects mentally. The participants were shown a picture of a figure and then 8 options below it. The subjects were asked to choose the option(s) that showed the figure rotated but not mirrored. This test consisted of 2 sections with 10 items in each. Participants were given 3 minutes to complete each section. The test was scored by adding up the number of correct responses. The higher the score, the better the participant's mental rotation abilities were.

Southern California Spatial Activities Questionnaire (SoCalSAQ; Munns et al., 2022)

This is a revised version of the original Spatial Activities Questionnaire (SAQ) by Signorella et al. (1986). This new questionnaire asked participants to identify activities they participated in and report how often they did them. The test consisted of 22 items from the original questionnaire by Signorella et al. (1986) and 31 items that were added by Munns et al. to provide more options that consisted of large-scale and updated spatial activities. Due to technical errors, only 38 of the 52 activities were presented. As a result, the following 3 of the 5

components were included, navigation, gaming and competition, and creative and artistic. The navigation and creative and artistic components had all their activities presented in the study as options, whereas the gaming and competition component was missing 2 out of the 11 activities. The questionnaire utilized a 6- point Likert scale, with the scale indicating different frequencies depending on the activity. The test scores were calculated by averaging the responses. The more frequently and the more activities the subject participated in, the higher their scores were.

The Paper Folding Test (PFT; Ekstrom et al., 1976)

This test measured the subject's spatial visualization abilities. During this test, participants were shown a picture of a folded piece of paper with a single-hole punch. The participant was then asked to look at the 5 options below the image and choose the one that showed what the paper would look like when unfolded. The test consisted of 2 parts. Part 1 had questions 1-10, and Part 2 consisted of questions 11-20. Due to a technical error, only part 2 of the test was completed. Subjects were given 3 minutes to complete. The correct answers were added up to get an overall score. The better the participant's spatial visualization abilities were, the higher their scores.

Childhood Wayfinding Experience (CWE; Lawton et al., 2002)

This looked at the participant's self-reported navigational experiences throughout their childhood. The questionnaire consisted of 2 sections. In each section, participants were asked a question and had to answer based on their experiences, first at age 8-10, then 11-13, and finally at 14-15 years of age. The first section asked participants about the distance they were allowed to travel independently from home. The second section asked how frequently participants went independently on errands. The questionnaire was scored by giving numerical values to each of the options. When scoring, 1 was assigned to the first option in both sections, and 5 was assigned

to the last. These scores were then added to give the final score. A high score indicated more independent and unrestricted travel during childhood.

Procedures

Students at Brescia University College in the Introduction to Psychology course (1015B) saw the study's description in the Brescia SONA system. After reading the description, students had the option of signing up. Those who signed up received an access link to the study in Qualtrics. Once in Qualtrics, the participants were first prompted to read the letter of information. The subject was asked to click continue if they consented and wanted to continue with the study. If the participant continued, they were directed to fill out the demographic question. This question asked where the participant spent the most time growing up as a child. After this question, the tests were completed in the above order. Following these tests, the participants were presented with the debriefing form and were asked to click to end the study.

Results

Two-tailed Pearson correlations were conducted to test the impact of childhood activities on later spatial abilities (see Table 1). This tested the relationship between each of the measures, including the Southern California Spatial Activities Questionnaire (SoCalSAQ), Childhood Wayfinding Experience (CWE), Card Rotation Test (CRT), Santa Barbara Sense of Direction (SBSOD) and part 2 of the Paper Folding Test (PFT). The means, standard deviations, and the number of participants for each measure can be seen in Table 2.

As seen in Table 1 and Figure 1, a significant, moderate, positive correlation was found between the Paper Folding test scores and the Card Rotation test. This indicated that as participants' scores on the Card Rotation Test increased, their Paper Folding test scores also increased. This correlation was expected as both measures test spatial visualization abilities. As

Table 1

Correlations of the Study Measures Without Splitting SoCalSAQ into Components

Variable		1	2	3	4	5	6
1. Hometown Population Density per km^2	*n*	—					
	Pearson's *r*	—					
2. CWE	*n*	60	—				
	Pearson's *r*	-.15	—				
3. SBSOD	*n*	60	69	—			
	Pearson's *r*	.15	.05	—			
4. CRT	*n*	61	69	69	—		
	Pearson's *r*	-.01	.07	.12	—		
5. PFT-pt. 2	*n*	60	70	69	69	—	
	Pearson's *r*	-.09	.02	.06	.46***	—	
6. SoCalSAQ	*n*	61	70	70	70	70	—
	Pearson's *r*	.11	.19	-.13	.06	-.07	—

Note. * $p < .05$, ** $p < .01$, *** $p < .001$

Table 2

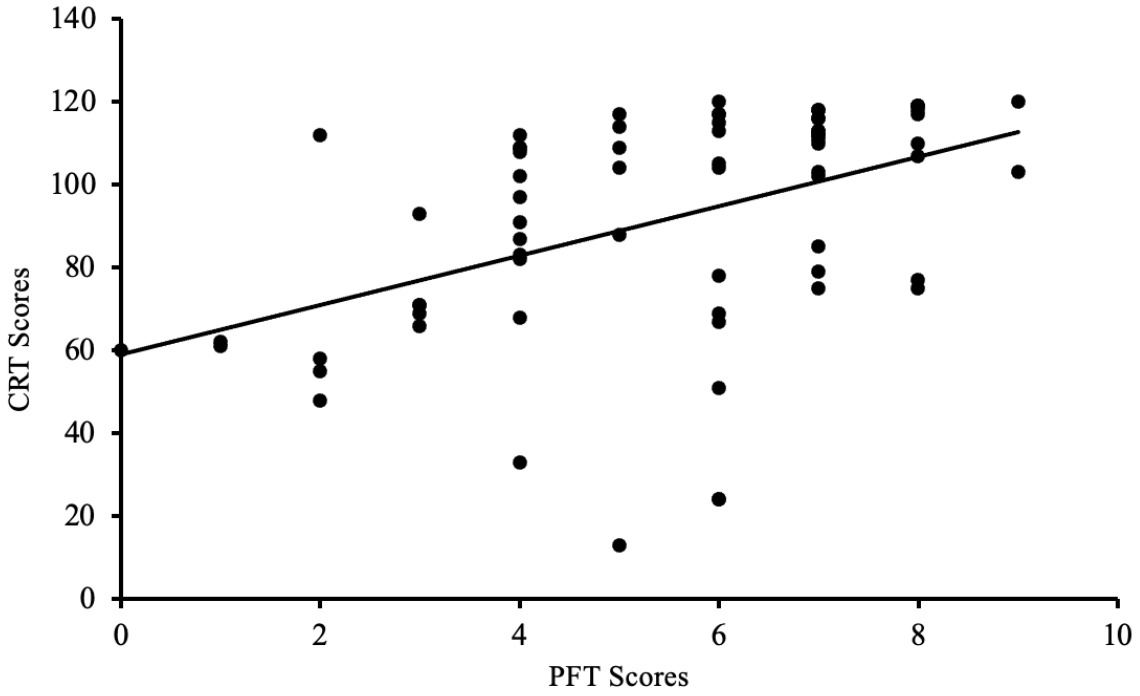
Study Measure Descriptive Statistics with SoCalSAQ Components

Variable	*n*	*M*	*SD*
SoCalSAQ- Navigation	72	32.63	7.96
SoCalSAQ- Gaming/Competition	72	13.90	5.25
SoCalSAQ- Creative/Artistic	72	21.00	8.91
SoCalSAQ	72	73.04	17.73
CWE	70	16.59	4.78
PFT-pt. 2	70	5.44	2.08
CRT	71	90.27	27.94
SBSOD	73	3.92	1.06
Hometown Population Density per km^2	61	1165.156	1184.158

Note. Higher means on the SoCalSAQ components indicate more participation in those kinds of activities. The higher means in SoCalSAQ overall indicate more participation in activities overall. Higher means in CWE indicate more frequent and more free wayfinding experiences when the participant was young. Higher means on PFT- part 2 and CRT indicate better spatial visualization skills. Last, higher means in SBSOD indicate a higher self-reported sense of direction.

Figure 1

The Correlation Between Scores on the Paper Folding Test and the Card Rotation Test



Note. Each dot represents a participant in the study. Higher scores on either of these measures indicate better spatial visualization abilities.

there were no other significant correlations between the measures, no regression analyses were conducted. The SoCalSAQ questionnaire was then divided into subcategories of activities defined by the SoCalSAQ questionnaire. These activity categories included navigation, gaming and competition, and creative and artistic. To identify any correlations between the specific groups and the other measures, another set of two-tailed Pearson correlations were conducted with these subcategories and the other measures (see Table 3). The gaming and competition component of the SoCalSAQ was not significantly correlated with SBSOD, CWE, CRT, or PFT-part 2. The other two components' correlations are stated below.

Navigation:

The navigation component of the SoCalSAQ was not significantly correlated with SBSOD or CRT. This indicated that participation in navigation-related activities was not correlated with a self-reported sense of direction or the ability to rotate a 2-D object mentally. The correlation analyses did, however, show a marginally significant, weak, positive correlation between the navigation component and CWE (see Figure 2). This indicated that participants who explored more frequently and freely when they were young, were more likely to engage in navigation-related activities, such as hiking and fishing. The navigation component was also approaching significance with a weak, negative correlation to the PFT (see Figure 3). This suggests that the more a subject participated in navigation-related activities, the worse they did on the PFT, indicating less of an ability to mentally manipulate an object. Given the non-significant result, this finding should be interpreted with caution.

Creative and Artistic Component:

The creative and artistic component was not significantly correlated with SBSOD, CWE, or PFT- part 2. This demonstrates that creative and artistic activities are not significantly

Table 3

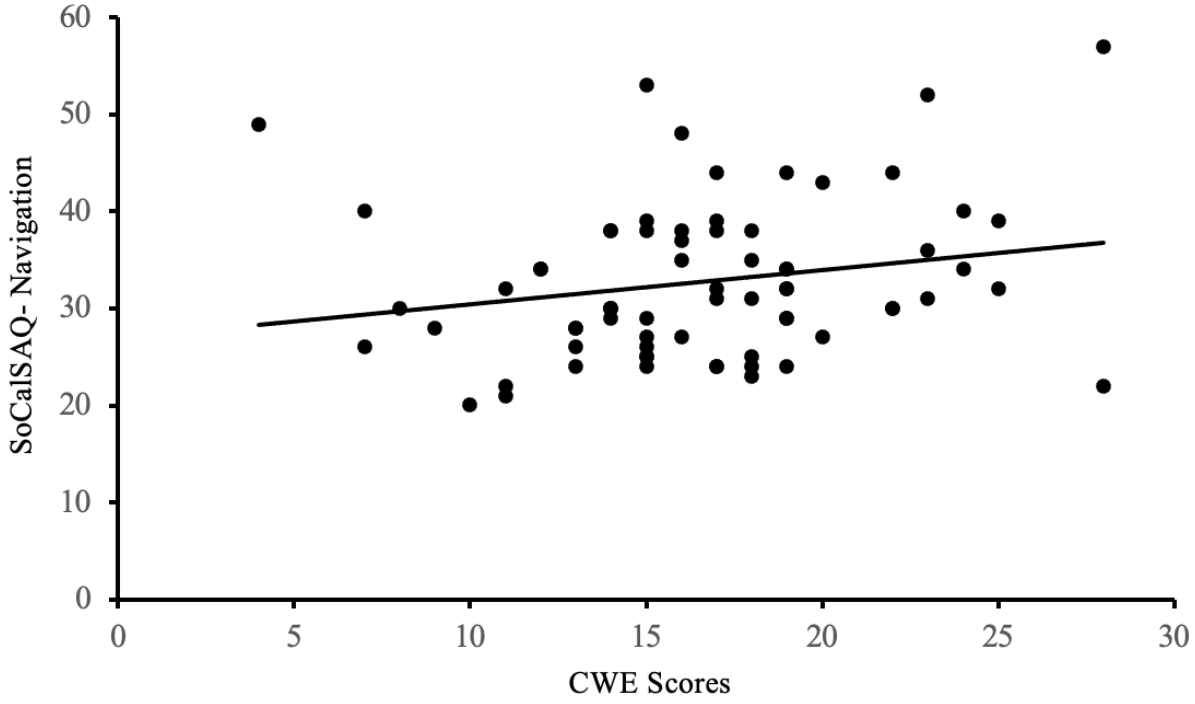
Correlations for Study Variables and the Activity Components in the Southern California Spatial Activities Questionnaire

Variable		1	2	3	4	5	6	7	8	9
1. Hometown Population Density per km^2	*n*	—								
	Pearson's *r*	—								
2. CWE	*n*	60	—							
	Pearson's *r*	-.15	—							
3. SBSOD	*n*	60	69	—						
	Pearson's *r*	.15	.05	—						
4. CRT	*n*	61	69	69	—					
	Pearson's *r*	-.01	.07	.12	—					
5. PFT-pt. 2	*n*	60	70	69	69	—				
	Pearson's *r*	-.09	.02	.06	.46***	—				
6. SoCalSAQ	*n*	61	70	70	70	70	—			
	Pearson's *r*	.11	.19	-.13	.06	-.07	—			
7. SoCalSAQ-Navigation	*n*	61	70	70	70	70	71	—		
	Pearson's *r*	.14	.21	-.08	-.13	-.22	.71***	—		
8. SoCalSAQ-Creative and Artistic	*n*	61	70	70	70	70	71	71	—	
	Pearson's *r*	.05	.17	-.10	.22	.04	.80***	.24*	—	
9. SoCalSAQ-Gaming and Competition	*n*	61	70	70	70	70	71	71	71	—
	Pearson's *r*	.11	.02	-.14	.03	.03	.74***	.39***	.48***	—

Note. * $p < .05$, ** $p < .01$, *** $p < .001$

Figure 2

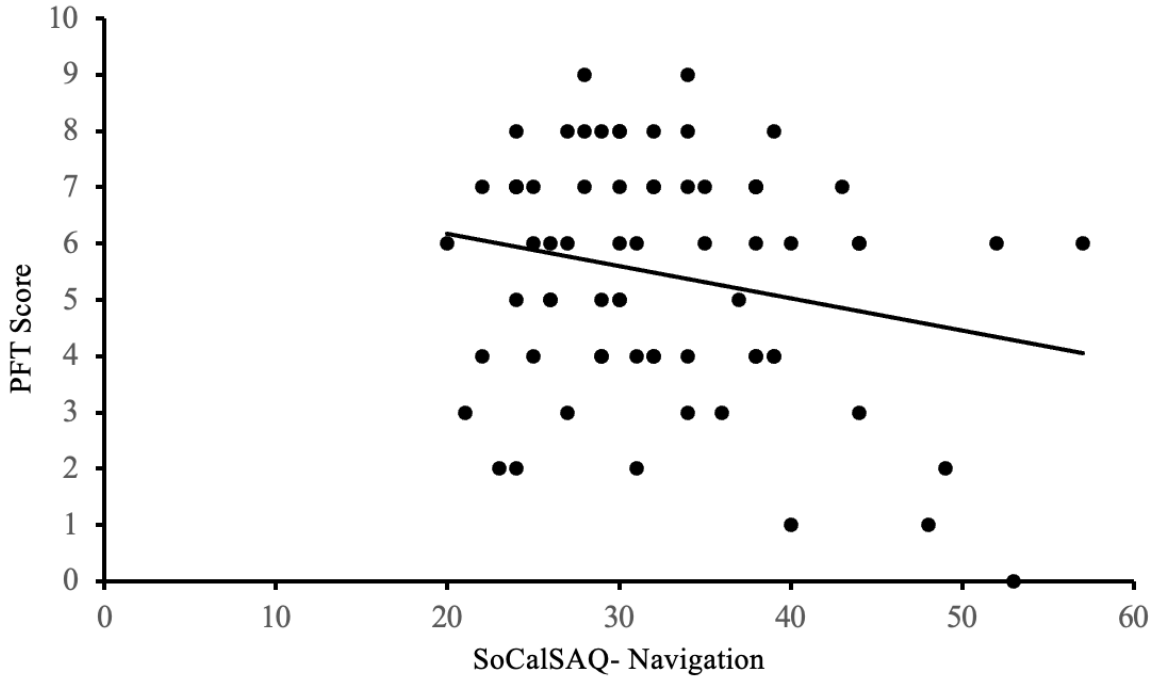
Correlation Between Scores on the Childhood Wayfinding Experience and the SoCalSAQ Navigation



Note. Each point represents the participant's scores. Childhood Wayfinding Experience shows a marginally significant, weak, positive correlation with the navigation component of the Southern California Spatial Activities Questionnaire.

Figure 3

The Correlation Between SoCalSAQ- Navigation and the Paper Folding Test



Note. Each dot represents the participant's scores. The navigation component of the Southern California Spatial Abilities Questionnaire showed an approaching significant, weak, negative correlation to the Paper Folding Test.

correlated with the self-reported sense of direction, early wayfinding experiences, or the ability to mentally manipulate an object. This component did, however, show an approaching significant, weak, positive correlation with CRT (see Figure 4). This correlation demonstrates that the more someone participates in creative and artistic activities, such as painting and ballet, the higher their CRT score was, indicating a stronger ability to imagine a 2-D object being rotated. Again, due to the non-significant finding, this result should be interpreted with caution.

Between Subcategories of the SoCalSAQ:

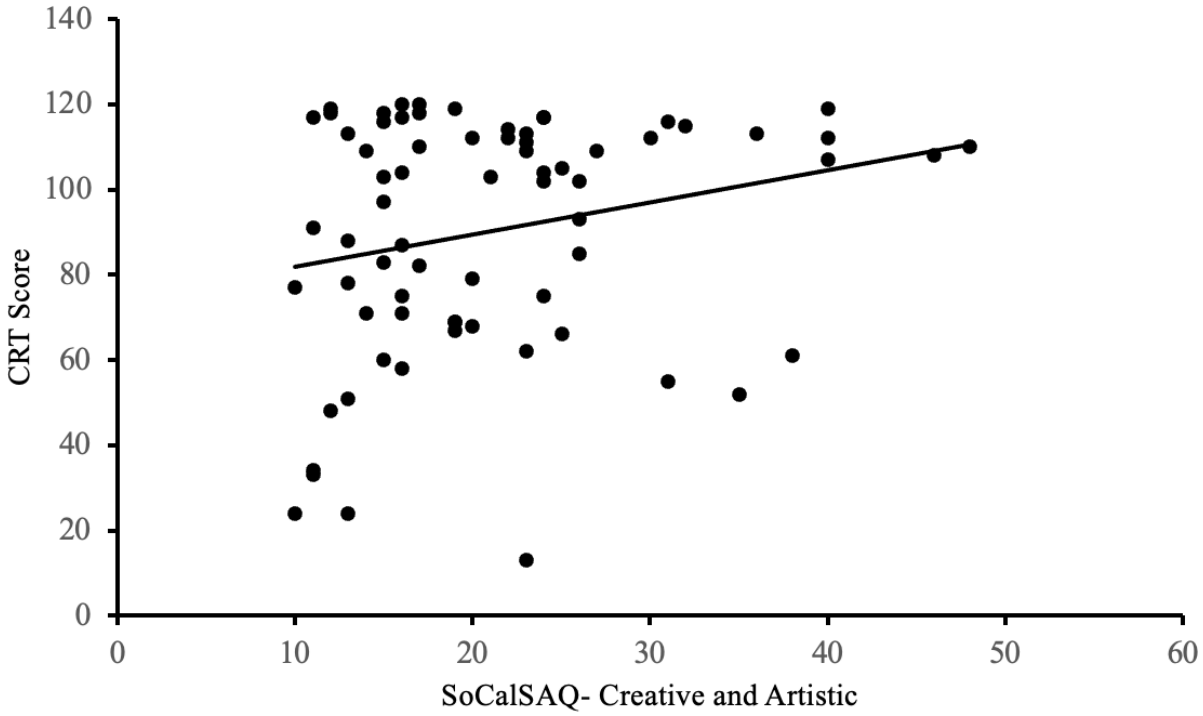
There were also several significant correlations between the SoCalSAQ components themselves. A significant, weak, positive correlation was found between the gaming and competition and the navigation sub-categories (see Table 3). This correlation indicated that the more frequently someone participated in gaming or competitive activities, the more they participated in navigation-related activities. The navigation and creative and artistic subcategories were also correlated with a significant, weak, positive correlation (see Table 3), indicating that the more someone participated in navigation-based activities, the more they also participated in creative and artistic activities. A significant, moderate, positive correlation was found between the creative and artistic subcategory and the gaming and competition component (see Table 3). This indicated that the more frequently the participant participated in activities related to gaming and competition, such as tackle football and chess, the more frequently they also participated in creative and artistic activities.

Hometown Population Density

When exploring the influence of hometowns on spatial activity participation and later spatial abilities, we hypothesized that the participants' hometowns would impact the kinds of activities they participated in and the development of their spatial abilities. We predicted that

Figure 4

The Correlation Between SoCalSAQ- Creative and Artistic and the Card Rotation Test



Note. Each dot represents the participant's score. The creative component of the Southern California Spatial Activities Questionnaire showed an approaching significant, weak, positive correlation with the Card Rotation Test.

participants who grew up in less densely populated and more rural areas would have more opportunities to explore extensive areas, in turn affecting their CWE scores. Additionally, we predicted that where a participant grew up and how rural it was would impact the kinds of activities that they participated in. In this study, with a sample of 71 participants, 61 grew up somewhere in Canada, and the other 10 grew up in other parts of the world. 2 participants were from Saudi Arabia, 1 from Germany, 2 from India, 2 from China, 1 from Taiwan, 1 from Barbados, and 1 from Syria. One of the participants identified that they grew up in Syria and Canada, so they were grouped in with the Canadian participants. Due to the small samples of hometowns outside of Canada, correlations were only done on Canadian hometown participants. Population densities were found for each reported hometown using Statistics Canada's Census Profile from 2021. The subdivision densities were found for each participant and were represented by the average number of people in that location per square kilometre. The mean and standard deviation in population density is shown in table 2. Ultimately, our hypothesis was proven wrong. The results showed that there was not a significant correlation between childhood spatial experiences and the density of the population in their hometown (see table 1). Additionally, there was no significant correlation between individuals' activities and the population density of where they grew up. This goes against findings that have shown that population density is a factor in the participation of behaviours that involve physical activity (Boakye et al., 2023).

Discussion

This study explored how childhood participation in spatial-related activities impacts a participant's later spatial abilities. We hypothesized that childhood activities identified as having a spatial cognition component measured in the Childhood Wayfinding Experience (CWE;

Lawton & Kallai, 2002) and the Southern California Spatial Activities Questionnaire (SoCalSAQ; Munns et al., 2022) would positively impact participants' spatial abilities in adulthood as measured by the Santa Barbara Sense of Direction (SBSOD; Hegarty et al., 2002), Paper Folding Test (PFT; Ekstrom et al., 1976), and Card Rotation Test (CRT; Ekstrom et al., 1979) in an all-women sample. Results demonstrated that the spatial visualization skills tested in both the PFT and the CRT were positively correlated. Additionally, as measured by the SoCalSAQ, creative and artistic activities approached a significant correlation with 2D mental rotation scores on the CRT. Navigation activities on the SoCalSAQ also showed a marginally significant correlation with childhood wayfinding experiences on the CWE and approached a significant correlation with spatial visualization abilities measured by the PFT. This suggests that certain spatial activities measured by the SoCalSAQ may have impacted women's later spatial abilities. Although there is a lack of strong or significant correlations, which is similar to past literature in the field (Munns et al., 2022). The current study also further explored whether the environment a participant grew up in would impact spatial abilities and activities. The results showed that there was not a significant correlation between childhood spatial experiences and the density of the population in their hometown. Additionally, there was no significant correlation between individuals' activities and the density of where they grew up. This goes against findings that have shown that population density is a factor in the participation of behaviours that involve physical activity (Boakye et al., 2023).

Ultimately, the results indicated that participants' activities were not significantly correlated with later spatial skills, which contradicts previous findings (Peterson et al. 2020; Doyle et al., 2012). Even though the present findings lack significant correlations, some current findings are approaching significance. This lack of significant findings may be the result of the previously

mentioned technical errors resulting in less data being collected. With correlations in past research often being weak (Munns et al., 2022), the current study's results may also not be too out of the ordinary.

Similar findings between this study and the Munns et al. 2022 paper that focuses on the development of the Southern California Spatial Activities Questionnaire (SoCalSAQ) can be seen in the correlations between study measures and SoCalSAQ components. Munns et al. found that navigation-related activities reported in the SoCalSAQ had a significant but weak correlation with childhood wayfinding experiences on the CWE. The results of the current study indicated a marginally significant effect between these two variables. This similarity should be cautiously interpreted due to the weak nature of Munns et al.'s finding and the lack of statistical significance of the current finding. Nonetheless, this trend supports the suggestion that the more frequently and freely the participant explored their environment as a child, the more they tended to participate in navigation-related activities such as camping and hiking in adulthood. Another finding from the Munns et al. paper that is similar to a finding from the current study was the correlation between the creative and artistic component of the SoCalSAQ and mental rotation measured by the CRT. Creative and artistic activities like painting and drawing were only approaching significance with 2D mental rotation abilities associated with the CRT, while Munns et al. found a significant but weak correlation between the same variables. Ultimately, even though the current study's findings with the SoCalSAQ were not statistically significant, there were similarities to Munns et al.'s findings.

The current study also looked to explore the relationship between population density and later spatial abilities. When looking at past literature, a study done by Boakye et al., (2023) studied the relationship between population density and physical activity. This study used the

long form of the International Physical Activity Questionnaire (IPAQ) to measure physical activity. This test identifies four main categories where people often participate in physical activity: occupation, transportation, housework, and recreation. The IPAQ also asks participants to identify their total physical activity level. The questionnaire asked participants to report the frequency and duration of their participation in different activities in the last seven days. Boakye et al. then investigated the correlation between where participants lived and the amount of physical activity they participated in. The researchers found that population density was related to lower levels of physical activity. In the current study, participants were first asked to report where they spent the most time growing up, and densities were then calculated. The current study's results indicated no significant correlations between population density and any of the study measures. This goes against Boakye et al. findings that report a correlation between population density and participation in activities with a physical component.

Some of the sex differences found in the Munns et al. (2022) paper may help to explain the current study's findings. Munns et al.'s paper indicated that there were significant sex differences in the gaming and competition component and the creative and artistic components. Specifically, more male-identifying individuals in their study tended to participate in gaming and competition activities, and more female-identifying individuals tended to participate in artistic and creative activities. Interestingly, even though Munns et al. identified that more women tended to participate in artistic and creative activities and numerous measures in their study showed significant correlations with this component, in the current all-women sample, there were no significant findings between the study measures and the artistic and creative component of the SoCalSAQ. With more women participating in these activities and numerous significant correlations in the Munns et al. mixed sample, one may have inferred that the correlations would

persist in an all-women sample, but this was not the case. With the current study consisting of 71 participants, all identifying as women, and the Munns et al. study consisting of 153 participants, 92 being female, the current study may have benefited and seen different results with a larger sample size.

A number of limitations of the current study should be noted. This study consisted of only female undergraduate students at Brescia University College in Ontario. Due to this, most participants we studied grew up in Ontario. As the popularity of certain activities may change depending on location, a lack of diverse hometowns may have acted as a limiting factor affecting the results. Additionally, due to the all-women sample, we were not able to make conclusions on how spatial activity participation impacts later spatial abilities in men or compare findings with men to our findings with women, limiting our ability to comment on gender differences. As previously mentioned, the current study also experienced a few technical errors. These errors caused the Paper Folding test results and the SoCalSAQ results to only include partial data. With less complete data, the findings of this study may not be completely comparable to previous reports. Additionally, due to the challenging nature of some of the tests and the length of the study, many participants did not fully complete all of the sections. Further research would benefit from larger sample sizes to potentially see more significant effects and to account for participants who may not fully complete all of the tests in the study. In-person testing may also be beneficial in future research. By conducting in-person tests, more participants may be willing to finish the study fully, and there would be more opportunities for participants to ask questions.

Future research should focus on environmental factors such as where someone grows up and how this impacts spatial abilities. With larger samples from different locations, researchers may be able to tell the impact of the environment and whether specific characteristics in an

environment, such as density, resources, etc., impact spatial abilities. Additionally, as the SoCalSAQ (Munns et al., 2022) is a new version of the original SoCal (Signorella et al., 1986) questionnaire, studies should continue using the latest version to gain more updated findings that can offer a modernized perspective to the literature.

The current study's results showed a non-significant association between a person's childhood activities and their later spatial abilities. The findings also suggest an association between 2D mental rotation abilities tested by the CRT and spatial visualization abilities tested by the PFT. There may also be an association between a person's participation in creative and artistic activities as measured by the SoCalSAQ and their 2D mental rotation abilities as tested by the CRT. The data may also suggest a relationship between an individual's participation in navigation-related activities such as camping or mountain biking, as measured by the SoCalSAQ, and their childhood wayfinding experiences, as tested by the CWE. Additionally, an association may be seen in the data between navigation-related activities and spatial visualization abilities as measured by the PFT. Further research needs to be done with larger sample sizes utilizing the SoCalSAQ. Additionally, samples from more locations need to be tested to better understand the factors that impact the development of spatial abilities.

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