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Updating the Spatial Activities and Videogame Survey for Use in Development Research

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Abstract

Childhood experiences and activities, including sports, videogames, and toys, have long been of interest in understanding cognitive development and later individual differences. In particular, the malleability of spatial reasoning suggests that early experiences, including a variety of spatial activities, may have a significant impact on the development of students' spatial ability skills. In the present study, we sought to update the most widely used spatial activity survey and propose a survey of videogame usage. Both surveys were administered to a large sample of adults with children aged 7 to 14, with a sample (N = 1210) diverse in race, ethnicity, and gender. We explored the survey's descriptives, scale design, and factor structure to support future use.

Keywords: spatial ability; spatial skills; cognitive development; extracurricular activities; survey; videogames; parent-report

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1. Introduction

During the critical years of child development, individuality begins to develop through an interplay between personal characteristics, preferences, and abilities (Tackett et al., 2009). This developmental trajectory is influenced by the experiences parents provide for their children and the exposure students have to different symbol systems in their schools. Thus, the peer and play environments children grow up in also play a significant role (Peterson et al., 2020), as these experiences can even influence the trajectory of eventual skill formation in adulthood. Verbal language, quantitative representations, and abstract and figural symbols are among the important symbol systems children use in their daily lives (Lohman & Lakin, 2011). Researchers have found that the use of symbolic systems to present spatial relationships or to represent 3D shapes in 2D drawings are less emphasized at home and in schools, beginning early with block play and continuing throughout activities in the early elementary grades. This leads to the implication that spatial skills may vary more among individuals due to differential exposure. As noted by Doyle et al. (2012, p. 119): "Our analyses also support the hypothesis that environmental factors, as reflected in the childhood practice of spatially related activities, are related to spatial performance in adulthood."

While children are readily provided with symbol systems of words and numbers at an early age, spatial symbol systems are arguably not as prioritized in school or other settings. This lack of exposure to spatial symbol systems—which involve manipulating real or imagined shapes and making sense of spatial relations—has led researchers to argue that spatial cognition and skill development may be more influenced by training and education compared to other broad abilities in the Cattell–Horn–Carrol hierarchical model of human abilities (Uttal et al., 2013; Sorby et al., 2013). Spatial skills have been linked to specific types of academic success at all educational levels (e.g., Atit & Rocha, 2020; Buckley et al., 2018; Cheng & Mix, 2014), and improving spatial skills is also associated with greater success in STEM career fields (Uttal & Cohen, 2012) where such skills are highly valued, such as math, engineering, chemistry, and the geosciences (e.g., Hsi et al., 2013; Wai et al., 2009).

The activities and experiences in which children engage are crucial for the development of their reasoning abilities. According to Hall and Nielsen (2020), play and leisure time comprise approximately 18% of a child's typical day, providing opportunities for exploring diverse interests that may not be covered in school. As a result, numerous studies have examined how both school and extracurricular activities, such as games, toys, and sports, contribute to students' cognitive skills, particularly their spatial reasoning development (e.g., McDougal et al., 2023; Zhu et al., 2023). Some studies in this area have used retroactive or parental surveys to explore the link between children's experiences and their spatial reasoning scores (Doyle et al., 2012; Peterson et al., 2020). Additionally, spatial activities lend themselves to higher instances of spatial talk, which can further promote spatial skill development (Swirbul et al., 2025).

Researchers investigating the association between childhood activities and spatial reasoning often utilize one of two activity surveys (Newcombe et al., 1983; Voyer et al., 2000 [expanded in Cherney & Voyer, 2010]), as well as a survey on video game experiences (Terlecki & Newcombe, 2005). However, given the changing cultural context in which children engage in a wide range of new activities, including digital ones, it seems appropriate to update these instruments. The survey most commonly used is about 40 years old (Newcombe et al., 1983), and it is important to capture the impact of a modern array of activities, including digital activities, on children's development. For instance, a study by the Pew Research Center (2015) found that in 2015, 90% of parents reported that their children aged 6 to 17 watched TV, movies, or videos on a typical day, while 79% reported their children played games on electronic devices. This highlights the significant changes in use of digital devices since the original surveys were developed.

Updating the activities survey to align with contemporary activities may also benefit researchers interested in understanding general trends in childhood activities. In this paper, we present the outcomes of our efforts to revise these existing tools for use by parents of children aged 7 to 14 years, allowing them to report on their children's extracurricular activities and preferences. This updated survey will be particularly valuable to researchers exploring how children's developmental trajectories are influenced by their spatial (or other) skills and subsequent development.

1.1. Prior Work with Activites Surveys

The most widely used activity survey in the field of spatial reasoning, along with a narrative describing its development, was published by Newcombe et al. (1983). The survey's content was initially generated through brainstorming session:

> "The three authors generated a list of 231 activities that might occur in a population of high school and college students. They consulted high school yearbooks and junior and senior high school students in an effort to be as inclusive as possible. They also broke down activities into skill levels (e.g., plain knitting, knitting

> with seams, knitting patterns; beginning and advanced tennis), since it seemed that elementary versions of many activities were not spatial, but more advanced or specialized versions were." (p. 379)

To refine their list, the researchers cross-referenced it with other developmental research, including a diary study of fifth graders. Their goal was to create a survey that high school or college students could complete, reflecting on their common activities when they were around 13 years old. The survey utilized a six-category rating scale, ranging from 1 (never participated) to 6 (participated more than once a week, during the relevant season if relevant). A complete list of the 81 activities used in the study by Newcombe et al. (1983) can be found in Appendix A. Undergraduate participants coded the activities as spatial or non-spatial.

Signorella et al. (1986) later shortened the scale to 30 activities. However, their version has not been as widely used as the original Newcombe et al. (1983) survey.

Voyer et al. (2000) proposed a slightly different activities survey, which they claimed was distinct from the Newcombe et al. (1983) survey. Nevertheless, they did incorporate some of the Newcombe et al. (1983) items. Voyer et al.'s (2000) survey was based on previous surveys exploring sex-stereotyped, spatially engaging toys (Serbin & Connor, 1979) and sports that require spatial skills (Hult & Brous, 1986). The survey included a few additional, clearly spatial toys based on Newcombe's survey. The resulting survey was much shorter than Newcombe's and included lists of 18 toys and 17 sports that were popular and distinguished by their level of spatial demand. Participants in the Voyer et al. (2000) study ranked their top 10 toys and sports based on their level of engagement with those activities during childhood, without specifying a particular age range.

The next significant development in spatial research using an activities survey occurred with Cherney and Voyer (2010). They combined and factor analyzed items from the previously mentioned surveys, as well as a few items from Bates and Bentler (1973). College-aged participants in Cherney and Voyer's (2010) survey were asked to respond to 138 items based on the following:

> "... clearly defined the period of childhood of interest as between the ages of 3 and 12. The participants were required to indicate for each item listed how frequently they practiced each of them as a child. ... The questionnaire used a visual analogue scale such that participants were required to place an (X) at any point along a 100 mm line with "never" as the starting point and "always" as the end point." (p. 92)

The analysis of this instrument resulted in 11 factors with varying levels of sex-typing (e.g., feminine non-spatial toys) and types of activities (e.g., feminine art, non-spatial; neutral balance activities). A definition of spatial sports was used based on Voyer et al. (2000): "takes place in an area with well-defined spatial borders, requires use of spatial relations, or involves a knowledge of physical principles (e.g., gravity) or a combination of these" (pp. 900–901). This longer survey included some specific activities and branded toys, such as K'nex, which may change too frequently to stay up to date.

A more recent investigation into spatial activities focused on the role of large-scale spatial skills such as navigation ability as well as looking at traditional small-scale spatial skills like mental rotation (Munns et al., 2022). Their findings confirm that activities have changed since the initial Newcombe et al. (1983) activities survey, and confirm that periodic updates of spatial activities surveys are necessary for their continued use and for appropriate measurement in this area. Other investigations have focused on expanding understanding of the role of video games and how they relate to cognitive skills, particularly spatial abilities (AlWhaibi et al., 2024; Bediou et al., 2023) or how digital

toys have changed children's play (Wang et al., 2022), providing additional evidence that activities require updating. This is particularly important considering the tendency of previous activities surveys in classifying activities and their spatial nature by gender, which may have incorrectly regarded feminized activities as non-spatial (Bartlett & Camba, 2023).

1.2. Updating the Spatial Activities Survey

In adapting the activities survey for parents of children aged 7–14, our main goal was to create a comprehensive list of activities that children are likely to engage in. We paid attention to toys and activities that were previously shown to correlate with spatial skills based on prior research and definitions (Cherney & Voyer, 2010). We chose to rely on parent reports as a starting point for assessing spatial activities because parents can reliably respond to longer surveys and are likely to have better reading comprehension. Additionally, parents of younger children are often the ones responsible for purchasing toys and scheduling activities. Previous surveys on spatial activities have primarily focused on adult participants reflecting on their own childhood activities, which may not accurately represent the time actually spent engaging in such activities. All of these factors contributed to our decision to utilize parent reports.

We were not interested in maintaining the gendered or sex-typed organization of the scales in prior work; therefore, we combined some activities that are often gender stereotyped but fundamentally similar in terms of spatial affordances (e.g., dolls and action figures, softball and baseball). We removed items that were out of date (e.g., touch typing), uncommon (e.g., water ballet), age-inappropriate (e.g., glass blowing) or redundant with other activities in order to minimize the length of the survey for maximum participation. We also omitted some items that were classified as non-spatial and gender neutral by Cherney and Voyer (2010) to further reduce survey length.

Additionally, we added items that the research team (our team was diverse in terms of age, gender, race, parental status and national origin) generated as modern equivalents of previous items or new forms of entertainment that have emerged in the last decade or so and that may involve some spatial demands. These include:

- Remote control car, robotics, or drone flying
- Reading articles or participating in internet chat rooms
- Playing video games (on a phone, computer, or console)
- Engineering (including building challenges or working in a maker space)
- Computer programming/app development
- Block play (including Legos, gears, Snap Circuits, or similar)

1.3. Updating a Video Game Survey

Given the explosion of digital gaming and mobile phones since the 1980s, as well as evidence that video game play can be linked to cognitive skills (Bediou et al., 2023; Polinsky et al., 2023), there was a clear need to expand the survey questions regarding video games. Terlecki and Newcombe (2005) developed a survey tool specifically related to video games and spatial development research. This instrument focused very generally on games and primarily asks if the respondent played games and for how long. Given the rapidly evolving landscape of gaming, we surmised these questions would be unlikely to yield much variability in a modern sample.

One survey question in this research did ask about the range and types of games students enjoyed. Specifically, Terlecki and Newcombe (2005) asked students to rate their top 3 video or phone app game categories from a list of 25 categories, with an opportunity to add "other." This list included categories based on theme (military, flight, adventure) as well as style of play (Massively Multiplayer Online Games, real-time strategy). In

our updated instrument, we hoped to create genres that may better reflect contemporary spatial-relevant game play. For example, navigating a video game world would likely have the same impact on spatial skills whether the player was engaged in a wargame (e.g., World of Warcraft) or exploration (e.g., Animal Crossing; Pokemon). We also wanted categories that would be easily understood by children and their parents.

As part of Cherney and Voyer's (2010) efforts to modernize the list of activities, two activities related to video games were included: "Video and computer games (two-dimensional)" and "Video and computer games (three-dimensional)." We were concerned that parents would not be able to distinguish between games that fall into two- and three-dimensional categories as it is not a common distinction made for games. Therefore, we did not include these distinctions in our instrument.

Recognizing that specific games would quickly become outdated, we explored genres of video games that might capture some of this variability in gaming activity as well as potentially associated spatial skills. Gold et al. (2018) provided a taxonomy of six types of games based on game design theory and other literature. See Table 1. Our list covered these same categories, with the exception of driving games and shooter games, which we considered to be part of the action type. We also included categories that we believed were less likely to have spatial components, such as board or card games and educational games. In the study by Gold et al. (2018), playing action games was associated with higher spatial scores, but none of the other types of video games accounted for significant variance in overall spatial skills. Construction games were associated with mental rotation scores. The categories we combined with action (shooter and driving games) did not contribute to any of their predictive models of spatial skills. Therefore, we argue that our 10 categories would reasonably capture the contemporary breadth of video games and be easily recognizable by respondents.

Table 1. Contrasting Genres with Gold et al. (2018).

Video Game Categories in This Present Study	Alignment to Gold et al. (2018) Categories
Action (shooter, arcade, fighting, stealth, survival)	Shooter games Driving games Action games and role-playing games
Puzzle or arcade (matching, speeded tasks)	Arcade and puzzle games
Board or card games (chess, solitaire)	Not present
Word games (crossword, trivia, vocabulary, foreign languages)	Not present
Other educational games (math, computer coding)	Not present
Simulation (Sims, Rollercoaster Tycoon)	Construction and simulation games
Open building (Sandbox, Minecraft, Roblox)	Construction and simulation games
Artistic (creating/editing music or videos)	Not present
Role playing or strategy (Dune, World of Warcraft, Age of Empires)	Action games and role-playing games
Sports simulations (Madden NFL, NBA2K)	Sports games

In addition to prior survey work, we consulted online guides (Pavlovic, 2020) and app stores (e.g., Google Play) to see the range of games and genres that most individuals would be familiar with. Each genre was provided alongside two to four examples of the most popular games at the time from Google Play. Appendix B shows the genres and images used to provide examples.

1.4. Current Study and Survey Development

We refined draft versions of the survey through a series of small tryouts. We then administered a pilot version of the survey to a sample of parents with children enrolled in summer camp programs. Based on those results, we administered the revised survey to a large, representative sample of U.S. parents with children in the target age range. To explain the evolution of our instrument development, we first present findings from Study 1 with a smaller sample and then describe how those findings motivated the changes to the survey in Study 2 with the larger sample.

2. Study 1 Methods

As part of a larger project around spatial reasoning, parents of students participating in a summer learning program were asked to complete the newly assembled spatial activities survey. Table 2 provides an overview of demographic characteristics of the sample. Parents responding to surveys were overwhelmingly women, highly educated, with above-average income. Asian parents were overrepresented compared to national demographics. Among the children, there was an overrepresentation of boys (59%), and their median age was 10 (range 7 to 14). Around 25% of students were reported as receiving services as an English language learner (ELL), which is somewhat higher than expected.

Table 2. Demographic Characteristics of the Two Samples.

Category		Sample 1 (N = 157)		Sample 2 (N = 1053)	
		n	%	n	%
Parent gender	Man	13	12.6%	438	41.8%
	Woman	90	87.4%	603	57.5%
	Non-binary	0	0.0%	8	0.8%
	Prefer not to answer	0		2	0.2%
	No response	54		0	
Parent race (not mutually exclusive)	Black	15	9.6%	127	12.1%
	Asian or Pacific Islander	27	17.2%	54	5.1%
	Native American or Alaska Native	1	0.6%	27	2.6%
	White	101	64.3%	848	80.5%
	Latine or Hispanic	10	6.4%	68	6.5%
	Other	1	0.6%	8	0.8%
Parent level of education	Less than a high school degree	2	1.9%	8	0.8%
	High school degree or equivalent	2	1.9%	117	11.1%
	Some college credits or trade school courses	3	2.9%	211	20.1%
	Associate's degree	4	3.9%	121	11.5%
	Bachelor's degree	13	12.6%	388	37.0%
	Master's or Specialist degree	39	37.9%	148	14.1%
	PhD, MD, JD	35	34.0%	33	3.1%
	Other	0	0.0%	2	0.2%
	Some graduate credits	5	4.9%	22	2.1%
	No response	54		3	

Table 2. *Cont.*

Category		Sample 1 (N = 157)		Sample 2 (N = 1053)	
		n	%	n	%
Household income level	Less than $28,000	1	1.1%	97	9.4%
	$28,000–53,000	8	8.5%	189	18.3%
	$53,001–75,000	4	4.3%	214	20.7%
	$75,001–100,000	15	16.0%	184	17.8%
	More than $100,001	66	70.2%	348	33.7%
	Prefer not to answer	2		8	
	No response	61		0	
Child's gender	Boy	85	59.4%	533	50.8%
	Girl	58	40.6%	509	48.5%
	Non-binary	0	0.0%	8	0.8%
	Prefer not to answer	0		1	
	No response	14		0	
Child's race (not mutually exclusive)	Black	11	7.0%	159	15.1%
	Asian or Pacific Islander	24	15.3%	75	7.1%
	Native American or Alaska Native	0	0.0%	30	2.8%
	White	69	43.9%	859	81.6%
	Latine or Hispanic	6	3.8%	98	9.3%
	Other	1	0.6%	11	1.0%
Child's English learner status	Received services as ELL	25	24.3%	302	28.8%
	Did not receive services	78	75.7%	747	71.2%
	No response	54		4	

We emailed parents of students in participating summer programs with an invitation to complete a consent form for their children to participate in the research study. Our human subjects research was overseen by the first author's Institutional Review Board (Protocol #21-03-4401). Parents were then invited to complete the survey about their child's activities. Our research questions were:

1. To what extent do participants use each of the rating scale points?
2. What activities do parents report most and least frequently?
3. What video games do parents report their children play?

2.1. Measures

The parent survey included our complete, revised activities scale with 25 toys and leisure activities, and 27 sports or athletic activities. Parents also completed the video game survey with 10 genres. The response scale for each ranged from 1 (never participated) to 6 ([participate] more than once a week).

2.2. Analyses

To address the first research question, we calculated the observed and relative frequency of responses in each rating scale category for the spatial activity items. Because the set of activities does not reflect a unidimensional latent variable, typical rating scale analysis methods, including examining the average measure of participants within each rating scale category for each item (Linacre, 2002; Wind, 2022), are not applicable to this instrument. The other research questions were addressed with descriptive statistics.

3. Study 1 Results

Figure 1 presents the average frequency of responses within each rating scale category across the activity items, and Table 2 presents a numeric summary of responses to the activity items. On average, more than half of the participants (63%) did not respond to each item. This excludes participants who exited the survey early, meaning these missing responses were intermittent, though frequent, skips. Among response options, participants used the lowest category (x = 1) most often (33%). Participants who reported their children participating in activities usually used the second, third, and sixth categories. On average, fewer than 10% of responses were in the fifth category. Overall, these results suggest that fewer response categories may be needed in subsequent administrations of the survey.

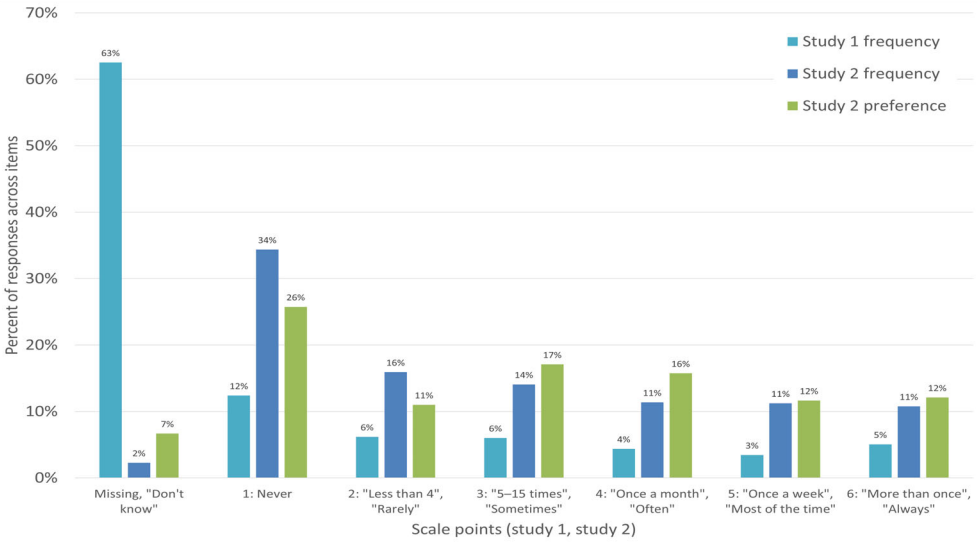


Figure 1. Average response frequencies for activity items. Original scale did not include "don't know" category, graph shows the non-response rate.

Common Activities

Table 3 shows descriptive statistics for the survey item responses. The most common activities reported by parents were watching TV, reading books, and playing video games. Swimming and biking were also common. Common activities classified as spatial include block play, playing a musical instrument, drawing, painting, sketching, and working on jigsaw puzzles. Soccer, hide and seek, and dodgeball were the most common spatially loaded sports.

Some activities had very low frequency with most students never engaging in the activity, and few students reported engaging frequently (most were low to medium frequency). These included pottery/sculpting, juggling, and knitting. For future studies, researchers could combine knitting into crafting. Juggling and pottery are both very spatially loaded and do not easily combine with other activities, they were retained. For sports, some of the least common activities are also spatially loaded and quite distinct from other sports (skiing, hunting, horseback riding, Lacrosse), and they were retained.

The most common video games included open building games (including Minecraft and Roblox), educational games, and word games. Role playing and sports simulation games had the lowest average frequency ratings. See Table 4.

Table 3. Summary of Study 1 Activity Responses: Sorted by Most Frequent.

Game or Toy	*M*	*SD*	Sport	*M*	*SD*
Watching TV or watching videos on the internet	5.79	0.72	Swimming	4.71	1.26
Reading books or graphic novels	5.58	0.70	Biking/cycling	4.35	1.34
Playing video games (on a phone, computer, or console)	5.42	1.11	Soccer	3.36	1.69
Block play (including Legos, gears, Snap Circuits, or similar)	4.55	1.50	Hide and seek, laser tag, or paintball	3.26	1.32
Playing a musical instrument	4.38	1.91	Dodgeball	2.91	1.51
Drawing, painting, sketching	4.26	1.44	Basketball	2.77	1.78
Board games or puzzles	4.23	1.23	Tennis, racquet ball, or squash	2.53	1.69
Card games	4.08	1.21	Martial arts	2.47	1.71
Building models	3.66	1.82	Frisbee	2.38	1.32
Engineering (including building challenges or working in a maker space)	3.57	1.64	Bowling	2.35	1.14
Mazes, puzzle books, tangrams	3.47	1.42	Baseball, softball, or tee-ball	2.31	1.39
Computer programming/app development	3.36	1.52	Diving	2.23	1.69
Remote control car, robotics, or drone flying	3.36	1.65	Dancing (including ballet, ballroom dancing, line dancing, or similar)	2.21	1.46
Coloring	3.32	1.50	Ping-pong	2.19	1.46
Jigsaw puzzles	3.23	1.45	Track and field (including high jump, indoor or outdoor track)	2.15	1.55
Action figures/dolls (including barbies or stuffed animals)	3.19	1.90	Football	2.04	1.45
Paper crafts (including origami or cutting crafts)	3.15	1.38	Rock climbing	1.87	1.00
Reading articles or chat rooms on the internet	3.12	1.94	Golf	1.85	1.39
Crafting or jewelry making	2.74	1.62	Figure skating/ice hockey	1.8	1.23
Chemistry experiments	2.65	1.33	Skateboarding	1.77	1.28
Climbing trees	2.64	1.30	Archery/darts	1.71	1.05
Photography	2.58	1.54	Gymnastics	1.67	1.08
Pottery or sculpting	2.12	1.04	Volleyball	1.6	1.18
Juggling	1.62	1.19	Skiing or snowboarding	1.54	1.07
Knitting	1.31	0.65	Hunting or target practice with a gun	1.47	1.05
			Horseback riding or horse jumping	1.44	0.67
			Lacrosse	1.27	0.87

Table 4. Summary of Study 1 Video Game Responses: Sorted by Most Frequent.

Video Game Genre	*M*	*SD*
Open building (Sandbox, Minecraft, Roblox)	4.54	1.67
Other educational games (math, computer coding)	4.02	1.54
Word games (crossword, trivia, vocabulary, foreign languages)	3.80	1.52
Action (shooter, arcade, fighting, stealth, survival)	3.46	1.90
Puzzle or arcade (matching, speeded tasks)	3.41	1.61
Board or card games (chess, solitaire)	3.33	1.53
Simulation (Sims, Rollercoaster Tycoon)	3.16	1.69
Artistic (creating/editing music or videos)	3.10	1.58
Sports simulations (Madden NFL, NBA2K)	2.96	1.74
Role playing or strategy (Dune, World of Warcraft, Age of Empires)	2.68	1.79

4. Study 1 Discussion

The results of our first study indicated a large number of nonresponses, but we were unable to tell if nonresponse was due to the child never participating or if it was due to parents' uncertainty about whether or how often their student had participated. Certain activities with low response frequency were excluded or condensed in future versions of the survey, but those that were distinct (such as pottery, juggling, lacrosse, etc.) were retained for future iterations. We also observed uneven scale use, with greater reliance on the extreme values of frequency. As a result of these observations, we did not think we could build upon the common activity results, as there was too much missing data. Thus, we added a "don't know" option to the scale and we also explored whether information about student's preference for activities might show greater meaningful variability than frequency had.

5. Study 2 Methods

Based on the results from the first sample, we wanted to compare the performance of the scale when we used different anchor point descriptors (preferences for activity vs. frequency of activity). We also saw that participants in the first study skipped a large number of items. Therefore, we added a "don't know" option to the scale and required a response to each question. We administered this modified survey to a large, representative sample of U.S. parents with children in the target age range (7 to 14).

For Study 2, we recruited a sample of 1000 participants using the Prolific research participant database. We restricted our sample to participants in the U.S. who had at least one child currently aged 7 to 14. In this sample, parents had a closer balance of men and women, although with an overrepresentation of white respondents. The educational level and income were more evenly distributed in this sample. A similar number of students received ELL services as in Study 1. As in Study 1, the median age for the children was 10 years (range 5 to 14 years). See Table 2. We focused on the following research questions in Study 2:

1. To what extent do participants use each of the rating scale points?
    a. Does this vary with preference vs. frequency anchor point descriptors?
2. What activities do parents report most and least frequently?
3. What video games do parents report their children play?
4. Do open-ended questions suggest additional activities or video game genres need to be added?
5. Is there a meaningful latent structure of activities?
    a. How do these structures align to prior work or spatial classification?

5.1. Survey Text

Because of the high number of missing responses by participants, we administered the same frequency scale while requiring a response to each item and adding a scale point for "don't know," because we assumed that some of the missing data in Study 1 was due to uncertainty. The "don't know" category was treated as missing for all descriptive statistics apart from the scale point frequencies. We used the same scale for the video game survey.

We were also curious if having parents respond about the preferences of their child might lead to a wider usage of the different scale points. To reduce the demand on participants, we did not provide the entire survey twice but instead selected 24 items that reflected both spatial and non-spatial toys/games and sports (similar to Voyer et al., 2000). We also omitted activities that had very high participation rates (e.g., watching TV) and very low rates (e.g., horseback riding). Table 5 shows the different anchor points used in each survey.

Table 5. Anchor Points.

	0	1	2	3	4	5	6
Study 1	---						
Study 2 frequency	Don't know	Never participated	Participated four or less times	Five to fifteen times	About once a month	About once a week	More than once a week
Study 2 preference	Don't know	Never wants to participate	Rarely wants to participate	Sometimes wants to participate	Often wants to participate	Most of the time wants to participate	Always wants to participate

5.2. Analysis

Descriptive statistics and scale analyses were conducted to answer the first three research questions. For question four, an open-ended question at the end of each survey section asked parents to write in any additional activities or game types. We analyzed these open-ended responses for additional categories and looked for ways to improve the survey so that all types of games were represented and so that parents understood which category common games might fit into. The final question necessitated an exploratory factor analysis to understand the number and types of latent factors present. We used maximum likelihood estimation and promax rotation to estimate the factors. We used theory, the Kaiser criterion (eigenvalue > 1), and parallel analysis to select the best fitting factor model.

6. Study 2 Results

We speculated there might be two main reasons for the high number of missing responses in Study 1. First, parents may have skipped items if they were not sure about their child's participation. Second, parents may have skipped items if their child never engaged in an activity. Figure 1 shows the frequency with which parents used each response option. The increase in the number of "never played" responses suggests that parents in Study 1 skipped those items that their child never engaged in. The "don't know" option was comparatively rarely used.

Similar to Study 1, the most common response was "never" for both frequency and preference. However, the distribution of preferences appeared more distributed, with slightly more usage of the 3rd and 4th scale point. Parents were less likely to select "never" compared to the frequency scale.

6.1. Descriptive Information: What Are the Most and Least Common Activities Reported by Parents?

Table 6 shows the descriptive information for the survey items. The most common activities for games and sports were the same as Study 1 (watching TV, reading, playing

video games, biking, swimming). Among the more spatial activities, block play ranked a little lower along with puzzles and drawing activities ranking higher.

Table 6. Summary of Study 2 Activity Responses: Sorted by Most Frequent per Category.

Toys/Games	Frequency		Preference	
	M	*SD*	*M*	*SD*
Watching TV or watching videos on the internet	5.58	0.97	--	--
Playing video games (on a phone, computer, or console)	5.44	1.16	--	--
Reading books or graphic novels	4.70	1.57	--	--
Drawing, painting, sketching	4.65	1.52	4.38	1.54
Coloring	4.30	1.62	3.91	1.58
Board games or puzzles	4.11	1.38	3.95	1.36
Block play (including Legos, gears, Snap Circuits, or similar)	3.87	1.68	3.62	1.61
Action figures/dolls (including Barbies or stuffed animals)	3.75	1.89	3.29	1.70
Card games	3.44	1.42	3.70	1.45
Paper crafts (including origami or cutting crafts)	3.10	1.59	3.19	1.61
Mazes, puzzle books, tangrams	2.98	1.43	3.10	1.45
Crafting or jewelry making	2.91	1.66	3.23	1.77
Playing a musical instrument	2.89	1.90	2.97	1.68
Jigsaw puzzles	2.88	1.32	--	--
Remote control car, robotics, or drone flying	2.73	1.53	--	--
Photography	2.72	1.63	--	--
Climbing trees	2.62	1.60	--	--
Building models	2.56	1.54	--	--
Reading articles or chat rooms on the internet	2.49	1.87	--	--
Computer programming/app development	2.42	1.77	2.83	1.80
Chemistry experiments	2.27	1.25	--	--
Engineering (including building challenges or working in a maker space)	2.13	1.45	3.12	1.45
Pottery or sculpting	1.83	1.19	--	--
Juggling	1.41	0.90	--	--
Knitting	1.32	0.87	--	--
Sports	***M***	***SD***	***M***	***SD***
Swimming	3.56	1.56	--	--
Biking/cycling	3.50	1.75	3.71	1.71
Hide and seek, laser tag, or paintball	3.27	1.48	--	--
Soccer	2.65	1.69	3.01	1.77
Basketball	2.57	1.71	2.99	1.76
Dancing (including ballet, ballroom dancing, line dancing, or similar)	2.39	1.75	2.88	1.82
Baseball, softball, or tee-ball	2.26	1.64	2.76	1.78
Bowling	2.14	1.03	3.36	1.74
Dodgeball	2.13	1.25	--	--
Frisbee	2.10	1.14	2.92	1.72
Gymnastics	1.84	1.43	2.39	1.72
Football	1.79	1.38	--	--
Skateboarding	1.74	1.21	--	--
Track and field (including high jump, indoor or outdoor track)	1.71	1.31	2.28	1.64
Martial arts	1.66	1.36	2.29	1.65
Archery/darts	1.65	1.08	--	--
Tennis, racquet ball, or squash	1.60	1.11	2.23	1.65
Ping-pong	1.59	1.00	--	--
Volleyball	1.57	1.07	2.27	1.64
Rock climbing	1.50	0.92	--	--
Figure skating/ice hockey	1.41	0.94	--	--
Hunting or target practice with a gun	1.40	0.94	--	--
Golf	1.39	0.83	--	--
Horseback riding or horse jumping	1.39	0.90	--	--
Diving	1.31	0.84		
Skiing or snowboarding	1.26	0.73	--	--
Lacrosse	1.12	0.61	--	--

Some of the most common activities that were classified as spatial activities in prior research (see Appendix A) included block play, playing a musical instrument, drawing, painting, sketching, and doing puzzles. Soccer, hide and seek, and dodgeball were the most common spatially loaded sports played. Dodgeball was less common in this larger Prolific

sample and spatially intensive activities like soccer, basketball, and dancing were more common. The low frequency activities were the same as for Study 1.

We looked at the bivariate correlations between ratings of frequency and preferences, using Spearman's rank order given the use of ordinal variables. We found that parents rated toys and games similarly (median $r = 0.71$, range 0.57–0.76) across the two scales, although clearly there is substantial non-overlap. Sports showed more variability (median $r = 0.59$, range 0.38 to 0.62). Biking showed the lowest correlation of frequency and preference ratings. This suggests the choice between frequency and preference is non-trivial for researchers using this type of scale.

6.2. Descriptive Information: What Video Games Do Parents Report Their Children Play?

Parents were asked the frequency with which their child played each of 10 genres of video games. See Table 7. Similar to Study 1, the most common type of video game played was open building (Minecraft, Roblox) where 50% of parents reported their child played these games more than once per week. The least common were sports simulations and word games. For sports simulations, 48% of parents reported their students had never played that type of game.

Table 7. Summary of Study 2Video Game Responses: Sorted by Most Frequent.

Video Game Genre	*M*	*SD*
Open building (Sandbox, Minecraft, Roblox)	4.77	1.64
Action (shooter, arcade, fighting, stealth, survival)	3.68	1.92
Puzzle or arcade (matching, speeded tasks)	3.56	1.54
Other educational games (math, computer coding)	3.38	1.68
Role playing or strategy (Dune, World of Warcraft, Age of Empires)	3.36	1.94
Simulation (Sims, Rollercoaster Tycoon)	3.32	1.83
Artistic (creating/editing music or videos)	3.29	1.88
Board or card games (chess, solitaire)	2.94	1.59
Word games (crossword, trivia, vocabulary, foreign languages)	2.89	1.64
Sports simulations (Madden NFL, NBA2K)	2.44	1.81

6.3. Descriptive Information: Do Open-Ended Questions Indicate Additional Activities Need to Be Added?

At the end of the survey, parents were asked to write in any games that their child played but were not included in the provided categories. We received 182 write-in suggestions. We processed the list by first removing the games that were listed as examples in the forced-choice questions (assuming parents overlooked those or misread the open-ended question). We looked for (1) categories of games that should be added and (2) commonly provided games that fit well into existing categories. Where games were frequently suggested, we added those as examples in the final revised survey, intended for future research.

Many parents wrote in games that we classified as action by conferring with app stores and the Steam platform. Most common were Fortnite and Legend of Zelda. A large number wrote in Animal crossing, Pokemon Go, dress up games, and make up simulators. Since the goal was to cluster games that are more likely to call upon spatial skills, we combined categories with that in mind. We also noted some overlap of labels that may have caused confusion. Therefore, we changed "Simulation" to "Hobby and Business Simulation" to include games involving navigating maps but ranging from Sims to Animal Crossing. The "Artistic" category, which mainly included less spatial games, was expanded to include "Art, Music, and Fashion." Revised category names and examples are shown in Table 8.

Table 8. Revised Video Game Categories and Examples.

Original Video Game Categories	Original Example Images	Revised Categories	Revised Example Images
Action (shooter, arcade, fighting, stealth, survival)	RaceCraft, Cars game, Touchgrind BMX, Subway Surfers, Minion Rush	Action and role playing (shooter, arcade, fighting, stealth, survival)	Fortnite, Call of Duty, The Legend of Zelda, Mario
Puzzle or arcade (matching, speeded tasks)	Tetris, Gem match, Candy Crush	Same	Tetris, Gem match, Candy crush, Temple Run, Subway Surfer
Board or card games (chess, solitaire)	Family board game, board games, Ticket to Ride, The Game of Life, Board games buddy	Board or card games (solitaire, Monopoly)	Family board game, board games, chess, solitaire
Word games (crossword, trivia, vocabulary, foreign languages)	Alphablocks, How does the human body work, Stack the States, Cross words, Kids Quiz	Word and educational games (crossword, trivia, vocabulary, foreign languages, math)	Alphablocks, Cross words, Kids Quiz, Stack the States
Other educational games (math, computer coding)	Logic puzzles, Hexlogic, King of Math, Lightbot	STEM educational games (math, computer coding)	Logic puzzles, Hexlogic, King of Math, Lightbot
Simulation (Sims, Rollercoaster Tycoon)	Burger Shop, Townscaper, City Island, Rollercoaster, Sims	Hobby and Business Simulation (Pet shop, Rollercoaster Tycoon, Animal Crossing)	Sims, City island, Burgershop, Animal Crossing
Open building (Sandbox, Minecraft, Roblox)	Lego, Block sun earth, Minecraft, Terraria	Same	Lego, Block sun earth, Minecraft, Terraria, Roblox
Artistic (creating/editing music or videos)	Kids Doodle, ChatterPix kids, Video Editor, FilmoraGo, Funimate	Art, Music, and Fashion (creating/editing music or videos, makeup and fashion simulation)	Kids Doodle, ChatterPix kids, Video Editor, Just dance, Karaoke
Role playing or strategy (Dune, World of Warcraft, Age of Empires)	Iron Marines, Among us, Warcraft, Clash of Clans	Strategy (Dune, World of Warcraft, Age of Empires)	Warcraft, Clash of Clans, Pokemon, Age of Empires
Sports simulations (Madden NFL, NBA2K)	Sim sports city, soccer game, Wii sports, NBA2k, Madden NFL	Sports games (Madden NFL, NBA2K)	NBA2k, Madden NFL, CSR racing, Mario Kart, Pool

For other activities, we had 215 write-in responses. Some activities that were mentioned multiple times included baking, chess, cooking, fencing, hiking, gardening, roller skating, theater, trampoline, and yoga. Some of these activities were omitted from the list because they are low incidence for children (yoga, fencing) while others (baking, roller skating, trampoline) are less likely to involve spatial skills based on how most children participate, so they were not of particular theoretical interest. We determined that none of the activities written required changes to the activities survey.

6.4. Exploratory Factor Analysis: Is There a Meaningful Latent Structure of Activities? How Do These Structures Align to Prior Work or Spatial Classification?

We used an exploratory factor analysis (EFA) using maximum likelihood estimation and promax rotation to explore the internal structure of the activity and video game item responses from a latent variable perspective. Exploring the internal structure of the responses is one source of validity to support the interpretation and use of survey scores (AERA et al., 2014). Specifically, we considered our results related to internal structure with reference to previous research and our theory regarding the construct under investigation. In our initial model, we posited four factors (spatial and non-spatial, activities and sports) based on prior work (e.g., Cherney & Voyer, 2010), although it was unknown how the

video games would affect that organization. Eleven eigenvalues met the Kaiser criterion (eigenvalue > 1), but the model did not converge and many of the factors accounted for little variation or only had one item loading on it. We examined the scree plot and decided to retain five factors based on the visual pattern. These five factors explained 35% of the variance in item responses. Results from a parallel analysis also supported retaining these five factors.

Table 9 provides the EFA results. Spatially demanding (as classified by prior work) toys, games, and sports appeared on all five factors. This included distinct scales for sports and toys/games. The highest loading toys and games on Factor 2 were block play, board games, and jigsaw puzzles. The highest loading sports (Factor 3) were basketball, football, and biking/cycling. Neither of these scales seem particularly gendered and capture many of the survey items. Similarly, a clear video game factor was present where students seem to play a wide range of video games (if they play any at all).

The other two factors are somewhat ambiguous but intriguing. The first factor included a range of toys, games, and sports. In our review of these items, the common thread seemed to be that this factor included activities that are stereotypically associated with higher socioeconomic status (rock climbing, lacrosse, figure skating, horseback riding). The activities loading on that factor were not so much expensive hobbies, but niche hobbies that may be stereotypically associated with white, U.S. culture—knitting, juggling, and photography. Toys and games that showed negative loadings on this factor were classic childhood activities including block play, action figures/dolls, and watching TV, further suggesting that the first factor reflects parents reporting their children engaging more in "elite" or unique activities or avoiding lower/middle-class activities.

The fourth factor may be female stereotyped but could simply be engaging more in crafts and hands-on activities. Activities loading most strongly on this factor included crafting and jewelry making, gymnastics, paper crafts, dancing, and reading books or graphic novels. These are also activities that can be done alone. However, we conclude it is female-typed because it shows a negative loading of football, sports simulation video games, and action video games, which tend to be stereotypically male activities.

Despite the difference between our five factors and our original expectation that the factors would be separated by the type of activity and its spatial nature, the latent structure of this survey is nevertheless in line with prior research. Specifically, we observed distinctions between toys and games, sports, and video games. Additionally, our finding of a female-stereotyped factor aligns with prior research, as spatial skills have a history of gender differences and male-stereotyped activities have been thought to be more related to spatial performance in the past (Bartlett & Camba, 2023). Lastly, the niche hobbies factor is likely related to socioeconomic status. Altogether, these results related to the internal structure of our survey provide validity evidence to support the interpretation and use of our survey.

In addition, the substantial and interpretable factor loadings with each dimension, low cross-loadings, and factor distinctions that correspond with theoretically meaningful domains (Fabrigar et al., 1999; Hair et al., 2019) provided additional evidence related to construct validity. Additionally, each factor showed adequate internal consistency—providing evidence related to the reliability and precision of our instrument (ω_t = 0.81, 0.83, 0.83, 0.80, 0.73, for each respective factor).

Table 9. Exploratory Factor Analysis Results (Based on Frequency Data).

Activity	Factor and Potential Label					Spatial Classified *
	1	2	3	4	5	
	Niche or Unique Hobbies	Toys/Games	Sports	Female Stereotyped	Video Games and Computers	
Knitting	0.572					X
Diving	0.531					
Juggling	0.493	0.282				X
Figure skating/ice hockey	0.486					X
Skiing or snowboarding	0.485					
Volleyball	0.475		0.217			X
Horseback riding or horse jumping	0.462					
Pottery or sculpting	0.461					X
Tennis, racquet ball, or squash	0.444		0.275			X
Rock climbing	0.437		0.266			
Lacrosse	0.426					X
Photography	0.413			0.276		X
Track and field (including high jump, indoor …	0.400					
Ping-pong	0.379		0.346			X
Golf	0.324		0.241			X
Playing a musical instrument	0.316					X
Block play (including Legos, gears, Snap …	−0.284	0.711				X
Board games or puzzles		0.705				
Jigsaw puzzles		0.626				X
Building models		0.622				X
Mazes, puzzle books, tangrams		0.617				X
Card games		0.503				
Engineering (including building challenges or …	0.302	0.488				New
Chemistry experiments	0.224	0.462				
Remote control car, robotics, or drone flying		0.457	0.387			New
Action figures/dolls (including Barbies or …	−0.217	0.427		0.357		
Other educational games (math, coding)		0.402			0.300	New
Board or card games (chess, solitaire)		0.381			0.359	New
Computer programming/app development	0.252	0.290				New
Basketball			0.688			X
Football			0.607	−0.227		X
Biking/cycling			0.591	0.207		
Baseball, softball, or tee-ball			0.540			X
Soccer			0.538			X
Dodgeball			0.521			X

Table 9. *Cont.*

Activity	Factor and Potential Label					Spatial Classified *
	1	2	3	4	5	
	Niche or Unique Hobbies	Toys/Games	Sports	Female Stereotyped	Video Games and Computers	
Frisbee			0.519			X
Hide and seek, laser tag, or paintball			0.427	0.332		X
Sports simulations (Madden NFL, NBA2K)			0.405	−0.382	0.247	New
Skateboarding	0.263		0.395			
Swimming			0.359	0.308		
Climbing trees		0.239	0.348			
Hunting or target practice with a gun	0.224		0.295			X
Archery/darts	0.252		0.282			X
Bowling	0.209		0.272			X
Drawing, painting, sketching				0.706		X
Coloring		0.234		0.694		
Crafting or jewelry making	0.238			0.615		X
Gymnastics	0.302	−0.201		0.485		X
Paper crafts (including origami or cutting crafts)		0.356		0.455		New
Dancing (including ballet, ballroom dancing . . .	0.280			0.419		X
Reading books or graphic novels		0.263		0.353		
Open building (Sandbox, Minecraft, Roblox)	−0.230				0.641	New
Playing video games (on a phone, computer . . .	−0.260				0.600	New
Simulation (Sims, Rollercoaster Tycoon)					0.594	New
Artistic (creating/editing music or videos)			−0.227	0.293	0.570	New
Role playing or strategy (Dune, World of . . .					0.565	New
Action (shooter, arcade, fighting, stealth . . .			0.241	−0.350	0.490	New
Puzzle or arcade (matching, speeded tasks)		0.347			0.467	New
Reading articles or chat rooms on the internet	0.307				0.378	New
Word games (crossword, trivia, vocabulary . . .		0.320			0.345	New
Watching TV or watching videos on the internet	−0.416			0.281	0.330	New
Martial arts	<0.200	<0.200	<0.200	<0.200	<0.200	

Notes. Bold = video games, italic = sports. Loadings of less than 0.2 were suppressed. Martial arts had no significant loadings. * Classified as spatial by Newcombe et al. (1983) or Cherney and Voyer (2010), indicated with an "X" in that row, or "New" if it was a new activity not in those prior measures.

7. Discussion

Our goal in this research was to provide descriptive and exploratory analysis of a modernized survey of childhood activities tailored to understanding the development of spatial skills. Through an iterative process of two separate studies, we updated and expanded the coverage of the original survey, demonstrating that our modernized measure is reasonably comprehensive and useful for contemporary research involving students' activities (between the ages of 7 to 14).

7.1. Initial Findings and Scale Descriptors

We found adding a "don't know" option to the rating scale reduced missingness. Parents seemed to skip items where they would otherwise indicate their student never engaged in that activity. This option also clarifies the scale by disentangling the lowest rating scale from cases where parents are not familiar with the activity or cannot judge if their student has participated in it.

Anchoring the scale on preference may be more effective since some of the activities will naturally occur less frequently (e.g., skiing, playing football) than others (e.g., playing games on a phone, reading a book). Using frequency as an anchor could confound sports schedules and feasibility with preference for the activity (e.g., loving American football but only playing it in the fall). Preference showed better usage of the scale points, suggesting six scale points provide useful differentiation. For a frequency scale, fewer scale points may be necessary.

Our analysis of correlations showed that parents distinguish between their frequency and preference ratings. Sports showed more disparity (r = 0.59) than toys and games (r = 0.71). Intriguingly, parents' average ratings of preference for sports were commonly higher than their frequency (a difference of 0.5 scale points on average), potentially due to some sports being more constrained in terms of schedule and opportunity, regardless of preference for that sport. For toys and games, the correlation was stronger, and the averages were similar across scales. This suggests toys and games allow for more congruence of these ratings.

These results indicate that the choice between frequency and preference is non-trivial for researchers as parents seem to attend to the scale and anchor descriptors. If researchers are interested in opportunity to learn or time on task, the frequency scale should be used. Other researchers may be more interested in motivational aspects related to preferences.

7.2. Common Activities and Their Spatial Features

The most common activities reported by parents were the types of activities we would expect, including watching TV, reading books, and playing video games. Hall and Nielsen (2020) used a time study diary to show that "Play and Social" activities made up 7.4% of children's free time and "Passive Leisure" captured another 10.5%. Within Play and Social, 43.5% was allocated to playing games, 6.4% to hobbies, and 5% to sports (unstructured), reflecting the categories investigated in the present study. Within Passive Leisure, 66.9% was allocated to TV, 30.4% to other media, and 2.8% to other.

This prior research suggests that children dedicate relatively little time to play and social activities. However, this time is also most likely to be shaped by the child's interests and predilections and may be essential to the differentiation of abilities as they develop. Investment theories (Coyle, 2022) suggest that specific cognitive abilities become stronger through the self-selection of opportunities to further cultivate some skills at the expense of others.

Beyond TV and books, we found other common activities include those classified as spatially demanding. These included block play, playing a musical instrument, drawing, painting, sketching, and working on jigsaw puzzles. Among sports, the most common

spatially demanding sports included soccer, hide and seek, and dodgeball. The most common video games included open building games (including Minecraft and Roblox), educational games, and word games.

Open building games are particularly interesting for spatial reasoning and researchers have explored their potential for learning as well as for assessment (Peters et al., 2021; Worsley & Bar-El, 2020). One observation from talking with the children involved in the larger Study 2 sample is that students can use these open building games in a variety of ways that increase or decrease the spatial demands. Minecraft, for example, hosts innumerable player-built mini-games spanning the genres of video games we studied here (restaurant simulators, action/shooting games, etc.). Capturing all of these mini-games was beyond the scope of the survey but could be explored in the future.

Future research, including some this research team intends to pursue, should explore the consistency of reporting by children and parents. Videogames seem especially likely to lead to different results depending on the source. Gentile et al. (2012) surveyed parents and children (ages 6–12) about the parents' monitoring of TV and video games and found weak correlations of reported video game and TV activities ($0.11 \leq r \leq 0.42$), Children in this study reported substantially more TV and video game time than their parents reported, and less parental monitoring of when and what they engaged with. They found the child reports were better predictors of academic performance.

Similarly, Lobel et al. (2014) studied video game usage and psychosocial health, eliciting parent- and child-reported video game usage as well as parent-reported psychosocial health for the child. They found that the children's video game usage was uncorrelated to psychosocial health, but it was negatively correlated for parent ratings. We expect, therefore, that student and parent ratings would differ, but it is unclear which source would be more accurate.

7.3. Extending the Activities Survey and Recommendations

The open-ended questions at the end of the survey yielded many additional entries. The suggested video games led to a redesign of the video game survey to better reflect the categories of games that parents suggested. The suggested activities and sports were found to be low incidence hobbies or repetitive of existing items. Future research should continue to offer the write-in option to ensure that survey respondents can provide additional categories of play.

Additionally, given that the activities young children participate in are constantly changing, particularly due to new toys and digital play (Wang et al., 2022), it is prudent to constantly update these activities surveys to properly represent the activities that children and their families participate in. This is particularly relevant as children's play has greatly shifted due to the COVID-19 pandemic (McIsaac et al., 2024).

We are currently conducting follow-up research focused on relating the existing survey to spatial assessments for children; results from these analyses will provide additional evidence related to the construct validity to support the interpretation and use of our survey.

7.4. Limitations

Our survey focused on U.S. samples only, serving as one important limitation. However, we developed our survey by building upon prior work that included both U.S. and Canadian participants (Cherney & Voyer, 2010). Baenninger and Newcombe (1995) based their research largely on perceptions of U.S. undergraduates, though Signorella et al. (1986) illustrated a spatial activities short form could be used in a German sample.

It is important to note that the COVID-19 pandemic was on-going at the start of this study and may have disrupted the activities surveyed here, as it was in various other domains (e.g., Ilari et al., 2022; Ostermeier et al., 2022). Whether childhood activities have

changed in general will be important to investigate in the future. However, this activities survey was updated based on data near the tail end of the pandemic, again highlighting the importance of updating older spatial activities surveys for use in more contemporary historical research contexts.

Additionally, the current iteration of the survey seeks to find overall patterns in children's spatial activities. This does not take into account individual differences and the way that personality may affect both activity preferences and spatial ability, such as varying player modes or profiles (Kinzie & Joseph, 2008; Vergara et al., 2023), interests (Su, 2020) or the way they may approach spatial tasks (Hegarty & Waller, 2005; McKee et al., 2025), among other aspects. Future work should investigate the role of individual differences and personality in what may cause children's activity preferences and spatial skills.

7.5. Conclusions

Our findings indicate that children's activities are changing over time periods, but also that children have common preferred activities. We combined decades of research on spatial activities surveys to develop a new survey that considers both this storied history as well as the changes and modernization of play that today's children encounter, such as video games and digital toys. Future work should build on this to further clarify children's frequency of participation and preference for certain toys, games and sports, as well as dig deeper into the spatial nature of these activities. These findings could support educators and schools in providing informal spatial training and support the development of spatial skills.

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Abbreviations

The following abbreviations are used in this manuscript:

STEM	Science, Technology, Engineering and Mathematics
ELL	English Language Learner
EFA	Exploratory Factor Analysis

Appendix A

Complete list of activities in the current study alongside surveys by Newcombe et al. (1983) and Cherney and Voyer (2010).

	Current Survey Tool	Cherney and Voyer (2010)	Newcombe et al. (1983)
Toys		Baby dolls'	
	Action figures/dolls (including Barbies or stuffed animals)	Barbie dolls and similar'	
		G.I. Joe dolls and similar'	
		Robots or transformers	
		Stuffed animals	
	Block Play (including Legos, gears, Snap Circuits, or similar)	Blocks'	
		Construction blocks	
		K'nex	
		Lego blocks	
		Lincoln logs *	
		Tinker toys *	
	Board games or puzzles	Board games *	
	Building models	Building model planes	Building model planes
		Building train or race car sets	Building train or racecar sets
		Model cars or airplane kits *	
	Card games	Cards	
	Chemistry experiments	Chemistry experiments	
	Climbing trees	Climbing trees	
	Coloring	Coloring	
	Computer programming/app development		
	Crafting or jewelry making	Crafts	Crochet (with seams)
		Crochet (with seams)	Embroidery (no pattern)
		Crochet (without seams)	Jewelry (mount stones)
		Embroidery (no pattern)	Leatherwork (with seams)
		Jewelry (mount stones)	Quilting
		Leatherwork (with seams)	Weaving (design own warp)
		Leatherwork (without seams)	
		Quilting	
		Weaving	
	Drawing, painting, sketching	Drawing (three-dimensional)	Drawing (three-dimensional)
		Drawing (two-dimensional)	Mechanical drawing
		Mechanical drawing	Painting (three-dimensional)
		Painting (three-dimensional) *	Sketch auto designs
		Painting (two-dimensional)	Sketch house plans
		Sketch auto designs	Sketch clothes designs
		Sketch clothes designs	
		Sketch house plans	
	Engineering (including building challenges or working in a maker space)	Make/fix radio, stereo, TV	Make/fix radios, stereos
		Electrical circuitry	
	Jigsaw puzzles	Puzzles	
	Juggling	Juggling *	Juggling
	Knitting **	Knitting (with seams)	Knitting (with seams)
		Knitting (without seams)	Knitting (multicolor)
	Mazes, puzzle books, tangrams	Mazes	
	Paper crafts (including origami or cutting crafts)		
	Photography	Photography	Photography (adjusting focus)
	Playing a musical instrument	Play musical instrument	
	Playing video games (on a phone, computer, or console)	Video and computer games (two-dimensional)	
		Video and computer games (three-dimensional)	
	Pottery or Sculpting	Pottery (wheel)	Pottery (wheel)
		Play doh or modeling clay	Sculpting
		Sculpting	
	Reading articles or chat rooms on the internet		
	Reading books or graphic novels		
	Remote control car, robotics, or drone flying		
	Watching TV or watching videos on the internet	Watching television	

	Current Survey Tool	Cherney and Voyer (2010)	Newcombe et al. (1983)
Sports	Archery/Darts	Archery	Archery
		Darts	Darts
	Baseball, softball, or tee-ball	Baseball *	Baseball
		Softball *	Softball
	Basketball	Basketball *	Basketball
	Biking/Cycling	Cycling	
	Bowling	Bowling	Bowling
	Dancing (including ballet, ballroom dancing, line dancing, or similar)	Dancing	Ballet (choreography)
		Ballet (choreography)	Ballet (pirouettes)
		Ballet (pirouettes)	Disco dancing (with falls)
		Tap dance	Tap dance (own routine)
	Diving	Diving	Diving
	Dodgeball	Dodgeball	Dodgeball
	Figure skating/Ice hockey	Figure skating	Figure skating
		Hockey (ice or field) *	Ice hockey
	Football	Tackle football	Tackle football
		Football	Touch football
	Frisbee	Frisbee	Frisbee
	Golf	Golf *	Golf
	Gymnastics	Gymnastics	Gymnastics
	Hide and seek, laser tag, or Paintball	Hide and seek	
	Horseback riding or horse jumping	Horseback riding	
		Jumping horses	Jumping horses
	Hunting or target practice with a gun	Hunting	Hunting
		Target shooting	Target shooting
	Lacrosse	Lacrosse	Field hockey
	Martial arts	martial arts	
	Ping-pong	Ping-pong	Ping-pong
	Rock climbing	Rock climbing	Rock climbing
	Skateboarding	Skateboarding	Skateboarding
	Skiing or snowboarding	Skiing (cross country)	Skiing (jumping)
		Skiing (downhill)	Skiing (slalom)
		Skiing (jumping)	Sledding (around obstacles)
		Skiing (slalom)	
	Soccer	Soccer *	Soccer
	Swimming	Swimming *	
	Tennis, racquet ball, or squash	Tennis *	Racquetball (beginning and advanced)
		Badminton *	Tennis (beginning and advanced)
		Racquetball *	Squash
	Track and field (including high jump, indoor or outdoor track)	Track and field *	Pole vaulting
		Running *	High jumping
		High jumping	
		Indoor track *	
		Jogging *	
		Pole vaulting	
	Volleyball	Volleyball *	Volleyball
Not used due to being out-of-date, age-inappropriate, redundant, or uncommon		Arranging furniture	
		Building go-carts	Building go-carts
		Carpentry	Car repair
		Cars and trucks *	Carpentry
		Climbing and riding toys *	Electrical circuitry
		Dish sets *	Glass blowing
		Doll furniture *	Horseshoes
		Doll house	Interior decorating
		Foosball	Layout for newspaper, yearbook
		glass blowing	Navigate in car
		interior decorating	Plumbing
		Layout for newspaper	Tailoring
		Map reading	Touch typing
		Marbles	Using compass

Current Survey Tool	Cherney and Voyer (2010)	Newcombe et al. (1983)
	Play kitchen objects *	
	Plumbing	
	Puppets *	
	Tailoring	
	Touch typing	
	Using compass	
	Air hockey	Air hockey
	Baton twirling (>1 baton)	Baton twirling (>1 baton)
	Baton twirling (toss in air)	Baton twirling (toss in air)
	Boating	Canoeing (shooting rapids)
	Bow and arrow	Fencing
	Broomball	Foosball
	Canoeing	Marching band
	Fencing	Shooting pool
	Hopscotch	Water ballet
	Horseshoes	
	Marching band	
	Ring toss *	
	Ringette	
	Sailing	
	Shooting pool	
	Sledding	
	Walking	
	Water ballet	
	Weight lifting	
	Wrestling	

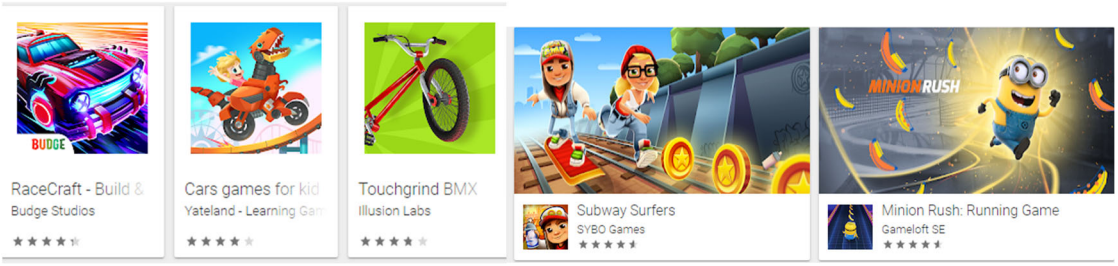
* Also presented in Voyer et al. (2000); ** Will be combined with crafting due to low incidence.

Appendix B

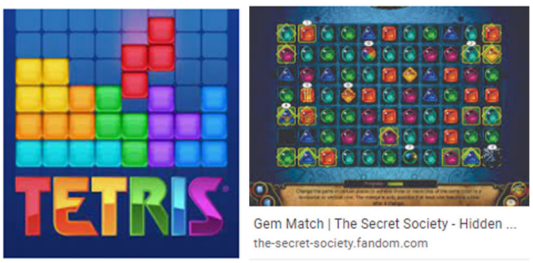
We are interested in the kinds of digital games your child likes to play. These can be games on a smartphone, a computer or tablet, or on a gaming console.

For each category of game below, please indicate how often your child plays with these kinds of games typically. The games provided are examples of each kind, but your child may play other titles. At the end of the survey, you can list other games your child likes to play that don't fit these categories.

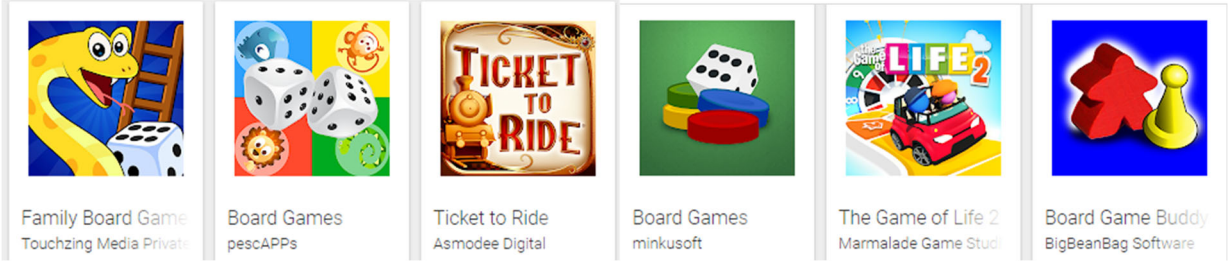
Action (Subway Surfers, driving)



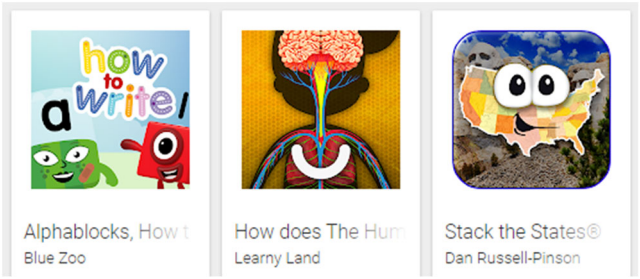
Arcade (matching, speeded tasks)



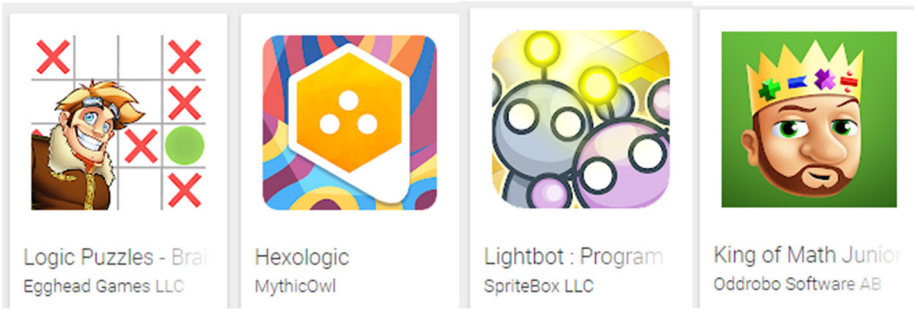
Board or card games (chess, solitaire)



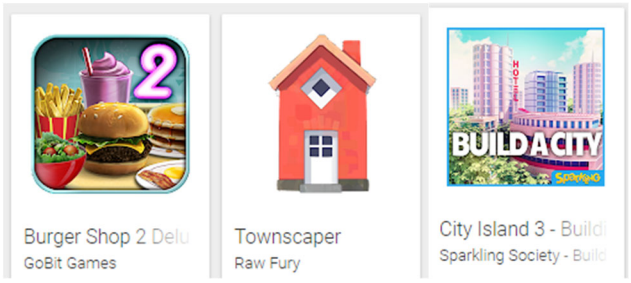
Word games (crossword, trivia, vocabulary, foreign languages)



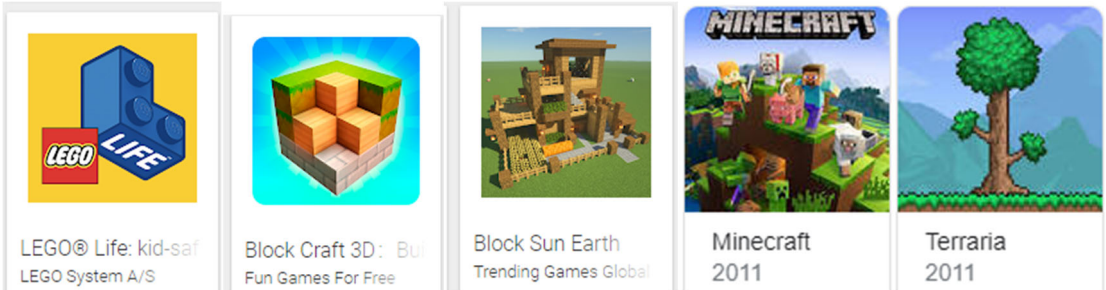
Other educational games (math, computer coding)



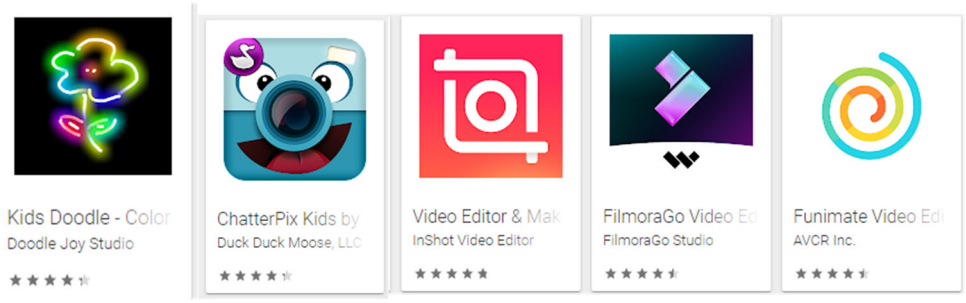
Simulation (Sims, Rollercoaster Tycoon)



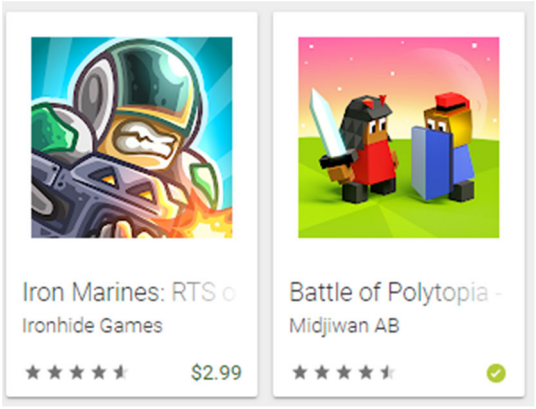
Open building (sandbox, Minecraft, The Sims, Animal Crossing)



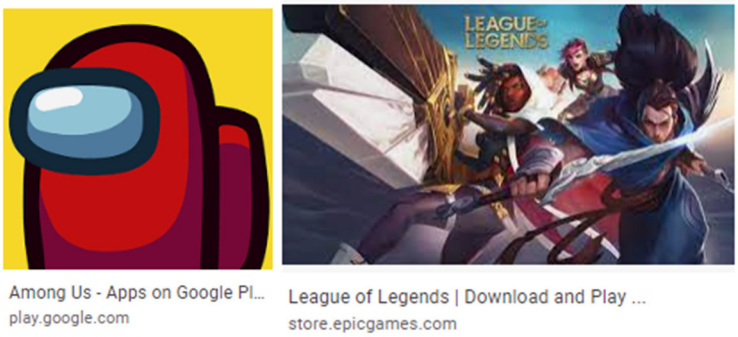
Artistic (creating/editing music or videos)



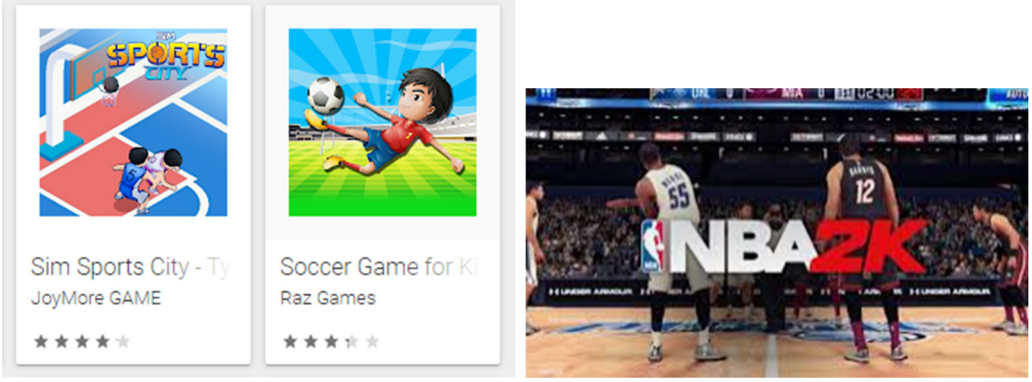
Real-time strategy (Dune, World of Warcraft, Age of Empires)



Shooter, role play, or multiplayer arena (Among Us, Halo, League of Legends)



Sports simulations (Madden NFL, NBA2K)



Are there other games that your child likes to play that don't fit into the categories above? Please list them here so we can improve this survey.

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