

1-2016

# Digital Media and Preschoolers: Implications for Visual Spatial Development

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## Recommended Citation

Keefe-Cooperman, Kathleen, "Digital Media and Preschoolers: Implications for Visual Spatial Development" (2016). *Faculty of Counseling & Development Publications*. 3.

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## RESEARCH ARTICLE

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### Digital Media and Preschoolers: Implications for Visual Spatial Development

Kathleen Keefe-Cooperman

*Long Island University Post*

Preschoolers' integrated technology usage was examined related to cognitive and visual spatial functioning. The participants consisted of 492 typically developing preschool children. Parent/caregiver reports of children's television viewing and digital technology usage, and WPPSI-IV intelligence scale scores and Visual Spatial Composite scores were examined. Preschoolers' screen time was also compared to a previous 2010 group to look for changes in television viewing patterns following an increase in digital device usage. The results provide evidence of an interaction between digital media usage and visual spatial abilities. Preschoolers with higher reported digital media usage had lower WPPSI-IV Visual Spatial Composite scores and Full Scale IQ scores, on average. Television viewing patterns have remained similar over time, but technological device usage has increased. Lower maternal education, lower SES, and being from a historically disadvantaged background were associated with greater usage time. Practical implications for prevention, early intervention, education and policy are discussed.

*Keywords:* visual spatial functioning; preschooler; screen time; mobile devices; integrated technology

The child has always been an active participant in their own developmental progress, and theorists have long identified the importance of fine motor functioning for preschooler growth. However, the preschooler's interaction within the larger world has changed with the advent of technology, and device usage results in less opportunity for traditional three dimensional interactions. Sensorimotor skills are key for early cognitive development in children (Piaget, 1952), and having less opportunities can impact development.

Digital media presents different exploration methods, and tends to be more isolative (Radesky et al., 2015). The use of digital media changes how the child uses their visual and spatial skills. The infant actively explores their environment through the use of motor skills, and this forms the base for their knowledge of the world. Socialization and exploration within the home or larger environment have historically been the proving ground for a youngster to test out new behaviors and ideas. Understanding how visual spatial functioning is related to later academic learning sets the stage for exploration into the impact of digital media on young children.

Visual and spatial abilities are progressively mastered as a skill set during childhood, and used in everyday life as an adult. The action of unlocking a door with a key, addressing an envelope, or hanging a picture on a wall are the result of playing with Legos, stacking blocks, or completing puzzles as a child. Thinking spatially allows us to focus on object location, shape, the relation to other objects, and what happens when the items move (Newcombe, 2010).

## SPATIAL SKILLS AND ACADEMIC FUNCTIONING

Cognition and motor functioning are intertwined. Diamond (2000) wrote that thought and perceptual-motor areas of the brain are not separate, but work in a complementary manner. Motor development provides the means for children to learn how to learn (Adolph, 2008). Preschoolers who engaged in more puzzle play were found to later have higher spatial transformation scores (Levine, Ratcliff, Huttenlocher & Cannon, 2012). Visual perception is key for future visual-motor coordination, and involves the assimilation of new and different information so as to build a base for cognition and emotion (Park & Oh, 2014).

Mastery of spatial skills has increasingly been linked to later academic achievement. Science, technology, engineering and math fields (STEM) build upon those early years of motor development (Uttal, Meadow, Tipton, et. al., 2013). Dinehart and Manfra (2013) found that fine motor manipulation skills were linked to math achievement in second graders. High schoolers with greater spatial abilities were tracked for eleven years, and were more likely to become adults working in the STEM field (Wai, Lubinski & Benbow, 2009).

Spatial skills acquisition is an ongoing process, and the loss of exposure at one point in time does not doom the child forever. Development is flexible, with ongoing opportunities for training (Uttal et al., 2013). Spatial skills acquisition in early childhood is typically a continuing and natural interaction between the child and their environment. However, skills that were initially underdeveloped can still be introduced, even at young ages. The key is to determine when a delay is present, identify habits that hinder visual spatial abilities, and actively promote greater mastery. This can then contribute to the basis for mathematical achievement in later years (Verdine, Golinkoff, Hirsh-Pasek & Newcombe, 2014).

## INTEGRATED TECHNOLOGY

The young children of today have never known a life without mobile devices, computers and television. Parents use technology as a means of facilitating learning. However, the quality of the digital software may not live up to the marketing claims. Grant et al. (2012) found that reading software programs lacked the full qualities needed for adequate instruction. Young children are digital natives who are drawn to mobile technology and able to easily maneuver through applications (apps). Numerous apps have been developed for preschoolers. Touch screen technology can be found in homes as well as in preschool settings, and the top grossing apps for young children sold on the iTunes website are advertised as “Education” (<http://itunes.apple.com/>). Yet studies have not yet been conducted on the validity of the educational potential. Parents often emphasize the educational benefit of digital usage based on the promotional marketing (Verenikina & Kervin, 2011), which may create a positive halo effect. The belief that there is a positive educational impact results in parents having an overall

optimistic view of their child using integrated technology, even without the research to back up these beliefs. This prevents parents from implementing practices that will offset digital usage, such as greater visual spatial play or time limits. There is also a pass-back effect (Chiong & Schuler, 2010), which is frequently seen in public when a parent gives their mobile device to the child. This serves to increase the accessibility for the youngster, as no one needs to sit in just one place to play on a computer anymore.

Many benefits are cited in relation to increased access to technology. Chiong and Schuler (2010) note that mobile learning provides a venue for underserved children to be able to access educational material, and that teachable moments can now occur anytime and anyplace. Apps have also been integrated into special education therapies. Bouvat, Kangas and Szczech (2014) cite the positive aspects of apps related to helping youngsters with special needs, and increasing academic learning. The ideas are correct in theory, but is integrated computer technology being used wisely? Evolving technological trends make it difficult stay current with research. The quickly changing technological landscape makes it difficult to conduct research on both the immediate and long-term effects of current media device usage. As an example, a study conducted on preschoolers 10 years ago would not focus on ease of access to technology both in and out of the home in daily life.

Parents also do not have a personal reference point from their own early life to compare technology usage with their children so as to provide proper governance. The current world has even been referred to as the “Digital Wild West” (Rideout, 2014). Adults often relate back to their own childhood experiences as a reference point for parenting. There is a lack of a reference point to use as a model, which results in ambiguity as to how to best handle screen usage (Plowman, McPake & Stephen, 2010). Parental screen time usage has also been strongly linked with the amount of time their child spends with technology (Lauricella, Wartella & Rideout, 2015), with those adults who use more technology favorably viewing usage by their children.

Digital usage is growing, as noted in the increase of children using a mobile device for media activity from 39% in 2011 to 80% in 2013 (Rideout, 2014). Differences in the use of integrated technology are also seen based on SES and racial/ethnic characteristics. Children who are poorer or of minority status have higher usage rates daily (Rideout, 2013). It is known that early exposure to television can be associated with detrimental developmental consequences in a variety of areas (Kirkorian, Pempek, Murphy, Schmidt & Anderson, 2009). Gawler Butler (1997) found that children in a first grade writing program who used television and video games delved less into the areas of feelings, attitudes, and understanding. Radesky et al. (2015) examined the frequency of mobile device usage in low income mother-child interactions, and found fewer interpersonal interactions as use increased. At-risk children already show less optimal sleep health, and related adaptive and cognitive functioning issues (Keefe-Cooperman & Brady-Amoon, 2014). Digital usage provides an additional detraction for already disadvantaged youth, and impedes educational efforts to close the achievement gap.

## SPATIAL DEVELOPMENT AND INTEGRATED TECHNOLOGY

Children physically interact with their environment, and this provides the explorative opportunities to develop and master spatial skills necessary for future daily functioning and STEM achievement. Understanding how digital usage impacts spatial development is key, as the type of motor interaction children have within their larger world is changing. Integrated

technology usage may be taking up time previously spent building blocks, or stacking pots on a kitchen floor. The way children play with a smart device is different.

Touch screen usage involves a physically different manipulation of objects. Fingers are used to move items across the screen in a two dimensional manner. There is no stacking or turning of items physically. In fact, only one hand is typically used to move digital media (Manches, 2011). Puzzles can now be completed on a touch screen without the child ever learning to physically turn the items so as to fit them into a space. Two dimensional media objects lack the perceptual cues of three-dimensional items, and negatively impact future application due to the limited nature of movement (Barr, 2013). The biomechanics of motor development are stunted by the limited range of motion and lack of opportunities to develop new movements (Jensen, 2005). Children are awake for only a certain amount of time daily, and the visual spatial skills gained through natural play are lessened when the child is spending their day on a digital device.

Much of the information about digital device usage impacting spatial development is anecdotal due to the rapid integration of technology into the daily life of preschoolers. The American Academy of Pediatrics (2015) suggests limits for screen time, but provides only minimal guidance on how to successfully help parents enforce healthy usage boundaries. Additionally and on a biological level, brain development is impacted by the changing way in which preschoolers are exploring their world. The neural infrastructure in the basal ganglia and cerebellum that arises during early cognitive motor exploration within the environment could be influenced by two dimensional rather than three-dimensional exploration (Grissmer, Grimm, Aiyer, Murrah & Steele, 2010). Lastly, digital media involves the portrayal of items on a screen, whether television or device. The symbolic representations of items may be open to different visual interpretation by the preschooler than a real life object (Claxton, 2011).

Researchers are racing to keep up with the ever-changing landscape of the preschooler's world, and how the integration of technology impacts learning. Understanding the impact of digital device usage related to visual spatial functioning will set the stage for the development of guidelines for screen time and digital media.

## PURPOSE

The purpose of the current study was to examine the association between screen time, defined as total amounts of time spent watching television and/or on a touch screen device, and visual spatial abilities among a sample of typically developing preschoolers. The sample is important, as information is needed regarding touch screen device usage and total screen time within the preschool population. Additionally relevant is the relation between technology usage and typically measured visual spatial abilities. Several hypotheses were tested (a) time spent on digital devices is significantly negatively associated with visual spatial abilities; (b) television viewing time has not decreased since 2010, and children have more total screen time due to the increase of digital device usage in society; and (c) there is a significant relation between overall screen time/digital device usage based and racial identification, SES, and maternal education.

## METHOD

### Participants and Procedures

A comprehensive evaluation process was conducted as part of the referral system to school district-based intervention services. Secondary data from the evaluations was used for this study. The geographic area included the New York City suburbs of Westchester and Rockland Counties. The measures used in this study were those approved by the school districts serviced. Children are evaluated for possible therapeutic services following a referral by the parents to the Committee on Preschool Special Education (CPSE) in their school district. Many of the referrals are based on preschool and pediatrician recommendations, as well as parental concerns. The primary focus of services is typically speech related, with the primary focus being articulation. Children with more significant needs tend to receive services in specialized therapeutic preschools, and those evaluations are conducted onsite. The secondary data represented in this study is of typically functioning children as a whole who present with issues such as articulation concerns, and a small amount with fine or gross motor concerns, or behavioral concerns. The children attended regular preschools and showed no major developmental difficulties. Many of the children also did not qualify for any service, and were undergoing an evaluation as a rule out.

CPSE serves all children 3 – 5 years of age through the school district in which they live, and the evaluation process includes multiple measures from psychologists, educators, and therapists specializing in the areas of concern. Additionally, children who receive therapeutic services (i.e. therapy to address a speech issue) up until the age of 3 years through Early Intervention are re-evaluated by CPSE prior to their 3<sup>rd</sup> birthday. Those children also receive the same battery of tests to determine if ongoing services are needed. Many children are found to no longer qualify for services due to progress made, and are not transitioned to CPSE (MGT of America, 2007). The psychological evaluation consists of a structured social history, the Wechsler Preschool and Primary Scale of Intelligence-Fourth Edition (WPPSI-IV), and either the Vineland Adaptive Behavior Scales II – Parent/Caregiver Rating Form (Vineland-II), or the Behavior Assessment System for Children, Second Edition (BASC-2) – Parent or Teacher. Many of the problem areas were developmentally minor, and resulted in a significant number of evaluated children no longer needing services or not qualifying at all for services through CPSE.

The vast majority of children evaluated attended preschool in a regular setting. The Full Scale IQ (FSIQ) scores for these youngsters were reflective of typically developing children, as seen in the median standard score of 101 and mode of 100. BASC-2 scores indicated that the overwhelming majority were in the Adequate range of adaptive functioning. Vineland-II scores also indicated that the children as a whole were rated as functioning in the Adequate range. The preschoolers matched the larger population as a whole. The similarity between these children and the general population on key variables, including cognitive and adaptive scores as well as caregiver interviews, contributes to its designation as a community sample (Wilkinson & Task Force on Statistical Inference, 1999).

*Participant Group 2014.* The study group was composed of 492 children with a mean age of 3.38 years ( $SD = .67$ ), and a median age of 3.1 years, and modal age of 2.8 years. The evaluations were conducted in 2013 and 2014. A total of 326 were male, and 173 were female. Parents or other primary caregivers reported their children's race/ethnicity as follows: European-American or White ( $n = 371$ , 74.1%), Latino or Hispanic ( $n = 45$ , 9%), Black or African

American ( $n = 51$ , 10.2%), and Asian or Asian American ( $n = 25$ , 5%). The sample was somewhat under representative of Latino, and African American populations, and slightly over representative of Asian children. However, the breakdown of the typically developing children in this study represents ethnic and racial trends based on the 2010 U. S. Census (Humes, Jones & Ramirez, 2011).

Parents/caregiver income information was not provided as part of the evaluation process. Matching zip code and U.S. median income census data has been used successfully to infer socioeconomic status (Mikolaitis, Aggarwal, Block & Jolly, 2008; King & Bearman, 2011). Determination of income was derived by matching the zip code of the preschooler with the U.S. 2010 median income census findings ([www.census.gov/2010census](http://www.census.gov/2010census)). The results found that 11.8% of the children ( $n = 59$ ) lived in at risk/lower income areas, 16.8% ( $n = 84$ ) lived in lower middle class areas, 44.3% ( $n = 221$ ) lived in middle class areas, and 25.9% ( $n = 129$ ) lived in upper middle class areas. This determination was completed on an individualized basis, and then the group was examined as an aggregate. The majority of female caregivers reported having attained at least a college degree (77.7%). The remaining caregivers self-reported having some college (14.1%), having a high school degree or its equivalent (4.6%), or not finishing high school (3.6%).

*Participant Group 2010.* A group of 612 typically developing children were evaluated between the years of 2005 and July of 2010, using the same structured social history. The two groups were similar to each other in all areas, including age, parental information and level of functioning. The sample was composed of children aged 30 – 45 months. The structured social history was verbally conducted with each parent caregiver and focused on prenatal and birth history, familial make up, and daily living patterns. This study focused only on preschooler media usage. Television viewing time was queried, as parents reported that as the primary form of screen time for children. This group was used as part of this study because this was prior to the digital explosion that occurred after 2011. This provided a base to examine different screen time usage patterns both prior to, and after the digital expansion of touch screen technology.

## Measures

*Parent/caregiver reports of digital device usage.* Parents or caregivers were asked to separately and specifically indicate their child's ongoing average television viewing time, television programming choices, and digital device usage time to determine overall screen time as part of a structured interview protocol conducted in 2013-2014. Both television viewing times and digital device times were collected.

*Wechsler Preschool and Primary Scale of Intelligence-Fourth Edition (WPPSI-IV).* The WPPSI-IV (Wechsler, 2012) is a psychometrically strong instrument for the assessment of cognitive ability and more explicit intellectual abilities in young children. The intelligence measure is administered individually to children ages 2.6 years to 7.7 years (Thorndike, 2014). The composite scores used for children in this study ages 2.6 years until 3 years, 11 months included a Full Scale IQ (FSIQ), along with the primary index scores of Verbal Comprehension (VSI), Visual Spatial (VSI), and Working Memory (WMI) (Thorndike, 2014). The composite scores for children aged 4 years until 7 years, 7 months include the Full Scale IQ

(FSIQ), along with the primary index scores of Verbal Comprehension (VCI), Visual Spatial (VSI), Fluid Reasoning (FRI), Working Memory (WMI), and Processing Speed (PSI). The norm referenced mean of the FSIQ and primary index scores is 100 (SD = 15), with larger scores indicative of higher cognitive abilities. The Visual Spatial Index was of primary focus.

The Visual Spatial index score assesses visual spatial processing, integration and synthesis of part-whole relationships, attentiveness to visual detail, nonverbal concept formation and visual-motor integration. Two subtests comprise the Visual Spatial Index. The Block Design subtest focuses on the child's ability to manipulate blocks so as to replicate patterns. The Object Assembly subtest assesses the child's ability to complete puzzles.

*Peabody Developmental Motor Scales – Second Edition (PDMS-2).* A subset of 138 children were administered the PDMS-2: Fine Motor Quotient, as part of the evaluation battery. The PDMS-2 (Folio & Fewell, 2000) measures gross motor skills using four subtests, and fine motor movement skills using two subtests. The measure has been found to be a reliable and valid test to identify children who may need therapies (Bunker & Kellers, 2003). The Fine Motor Quotient was used for this study, and the score is derived from a Grasping subtest and a Visual-Motor Integration (VMI) subtest. The Grasping subtest examines the ability of a child to use their hands. The VMI subtest measures a child's ability to use visual perceptual skills to perform complex eye-hand coordination. Building with blocks is one example of a task assessed for VMI. The measure has reliable and valid scales, and is a standardized instrument primarily used for individual assessment of children from birth until 6 years of age. The norm referenced mean is 100 (SD = 15).

## RESULTS

### Results by Hypothesis

*Digital device usage and visual spatial abilities.* The results of a bivariate correlation analysis examining digital device time usage, WPPSI-IV VSI and PDMS-2 FMQ scores can be found in Table 1. The first hypothesis, that time spent on digital devices would be negatively associated with visual-spatial abilities was supported. The results showed a statistically significant negative correlation between the amount of time spent on a digital device and the WPPSI-IV VSI,  $r(435) = -.10, p = .037$ . The correlation between digital device time usage and the PDMS-2 FMQ was not statistically significant,  $r(132) = -.063, p = .47$ . because of the smaller sample size. The results also showed a statistically significant negative correlation between the amount of time spend on a digital device and overall WPPSI-IV FSIQ scores,  $r(435) = -.20, p < .001$ . The negative correlation between the WPPSI-IV VSI and digital device time usage is uniform throughout. There is no threshold level whereby digital device time usage is associated with lower WPPSI-IV VSI. Any digital device usage was associated with lower WPPSI-IV VSI scores.

TABLE 1  
Bivariate Correlations Among WPPSI-IV Visual Spatial Composite Index, Smart Device Usage Time, and PDMS-2 Fine Motor Quotient

	1	2	3	4
1. WPPSI-IV Visual Spatial	--	-.10*	.27	--
2. Smart Device Usage		--	-.06	-.20**
3. PDMS-2 FMQ			--	--
4. WPPSI-IV Full Scale IQ				--

\*  $p < .05$

*Television viewing time between 2010 and 2014 participants.* An independent samples  $t$  test was conducted to examine the mean number of hours of television watching between the 2010 and 2014 groups. See Tables 2, 3 and 4 for the screen time and digital device usage time of the two groups. Statistical assumptions of normality, equality of variances, and independence were found to be tenable. On average, children from the 2010 time point ( $n = 612$ ) watched 1.84 hours of television per day ( $SD = 1.08$ ), while children from the 2014 time point ( $n = 333$ ) watched 1.87 hours of television per day ( $SD = 1.18$ ). This difference (.035 hours,  $SE_{\text{Difference}} = .076$ , 95% CI  $-.185, .114$ ) was not statistically significant  $t(943) = -.466$ ,  $p = .641$ . The difference represented only a very small effect. The 2014 group watched about the same amount of television, and had additional screen time through digital usage. The 2014 preschooler group had higher daily total screen time amounts as a result. Additionally, on average, children who were reported to watch greater amounts of television had higher amounts of technology usage. There was a statistically significant negative correlation between increased television viewing patterns and WPPSI-IV FSIQ scores,  $r(500) = -.14$ ,  $p < .001$ .

*Digital media time usage amongst ethnic/racial and SES groups, and differing maternal education levels.* A One-way Analysis of Variance (ANOVA) was used to examine whether reported digital device time usage differed amongst European American, African American, Latino(a), and Asian preschoolers. A very small number identified as Multiracial. Due to the limited number of participants who identified as multiracial, their scores were not included in the ANOVA results.

Tables 2, 3, and 4 present the 2014 television viewing times, digital device usage time, and total screen times for the racial/ethnic, SES, and maternal education groups in hours and minutes. The WPPSI-IV Visual Spatial mean scores and standard deviations are also shown. The tables also show the 2010 television viewing amounts by group. Table 2 specifically depicts the usage for each of the five ethnic/racial groups. As shown in Figure 1, there was a statistically significant effect of amount of digital device time usage for the different groups [ $F(3, 447) = 9.601$ ,  $p < .001$ ]. The results of Games-Howell post-hoc tests can be found in Figure 1 and indicated that European American preschoolers reported statistically significant less digital device time usage than African American participants, but not Latino(a), and Asian participants.

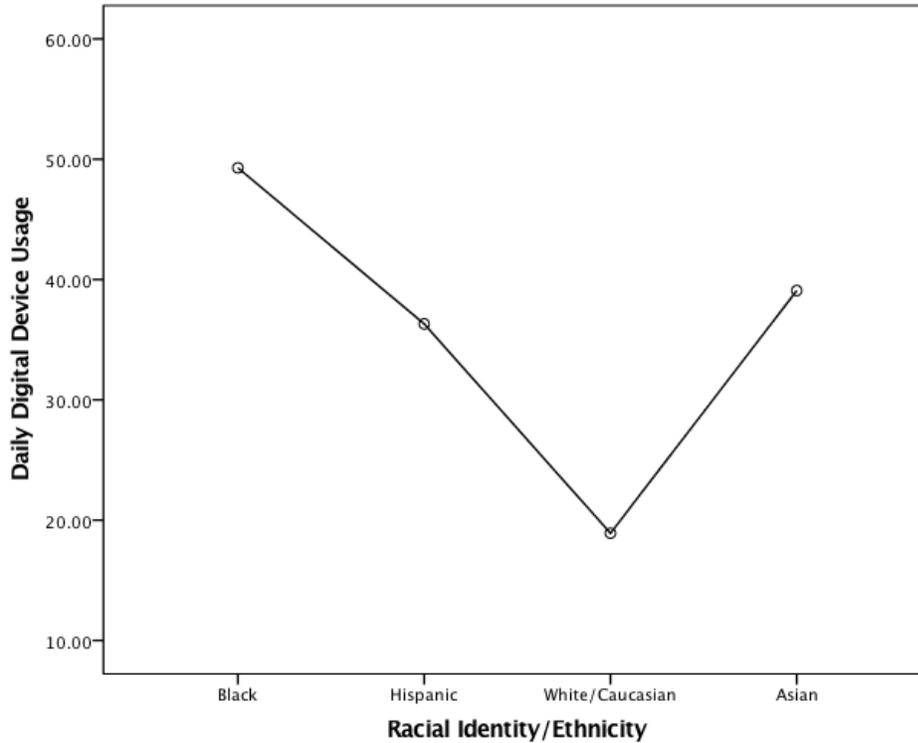


Figure 1. Digital Device Time Usage and Racial Identity/Ethnicity

Note: European American preschoolers reported statistically significant less digital device time usage than African American participants, but not Latino(a), and Asian participants.

Ethnic/racial identity is related to digital device time usage. The mean number of minutes of digital device use reported by European American preschoolers ( $M = 18.91$ ,  $SD = 35.77$ ) reported 20 minutes less daily digital device usage than the Asian group ( $M = 39.08$ ,  $SD = 65.56$ ), about 17 minutes less than the Latino(a) group ( $M = 36.32$ ,  $SD = 44.76$ ), and 30 minutes less than the African American group ( $M = 49.29$ ,  $SD = 62.3$ ). The results can be viewed in Table 2.

TABLE 2  
Television Viewing Times, Smart Device Usage, and Total Screen Time in Racial/Ethnic Identity from the 2010 and 2014 Preschooler Groups

Racial Identity/ Ethnicity	<i>n</i>	Television <sup>a</sup> Time	Digital Device <sup>b</sup> Time	Total Screen <sup>a</sup> Time	WPPSI-IV VS
European American					
2010	708	1 – 2 hrs		1 – 2 hrs	
2014	340	1 – 2 hrs	15 – 30 min	1 – 2 hrs	97.73 (11.31)
African American/Black					
2010	53	2 – 3 hrs		2 – 3 hrs	
2014	49	2 – 3 hrs	45 – 60 min	> 3 hrs	88.2 (12.39)
Latino(a)					
2010	47	2 – 3 hrs		2 – 3 hrs	
2014	38	2 – 3 hrs	30 – 45 min	2 – 3 hrs	88.67 (10.44)
Asian					
2010	39	1 – 2 hrs		1 – 2 hrs	
2014	24	1 – 2 hrs	30 – 45 min	2 – 3 hrs	96.92 (10.71)
Total					
2010	847	1 – 2 hrs		1 – 2 hrs	
2014	451	1 – 2 hrs	15 – 30 min	2 – 3 hrs	92.88 (11.21)

*Note.* WPPSI-IV Visual Spatial (VS) Composite Score is derived from the Block Design and Object Assembly Subtest Scores;  $M = 100$ ,  $SD = 15$ . <sup>a</sup>Television and total screen usage time have been collapsed into time categories: < 1 hour; 1 – 2 hours; 2 – 3 hours; > 3 hours. <sup>b</sup>Digital device usage time has been collapsed into categories: 15 – 30 minutes; 30 – 45 minutes; 45 – 60 minutes.

ANOVA was also used to examine whether reported digital device time usage differed amongst SES groups, and can be viewed in Figure 2. A very small number of participants identified as extremely high SES, and their scores were not included in the ANOVA results. Mean digital device usage was statistically significant by SES group [ $F(3, 448) = 12.043$ ,  $p < .001$ ]. See Table 3 for the time usage for each of the SES groups. The results of Games-Howell post-hoc tests indicated that parents in the “at risk” income level reported statistically significant greater amounts of digital device time usage than those in the lower middle class, middle class, and upper middle class.

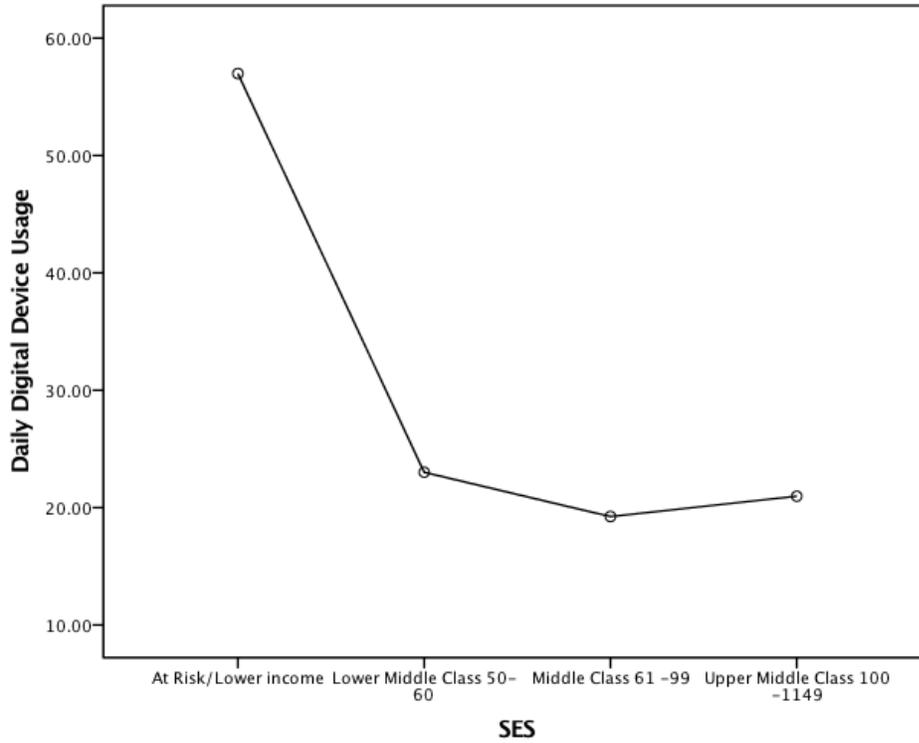


Figure 2. Digital Device Time Usage and Socioeconomic Status

*Note:* Parents in the “at risk” income level reported greater statistically significant digital device time usage than those in the lower middle class, middle class, and upper middle class.

TABLE 3  
Television Viewing Times, Smart Device Usage, and Total Screen Time in Minutes for Socioeconomic Groups from the 2010 and 2014 Preschooler Groups

SES Group	<i>n</i>	Television Time	Digital Device Time	Total Screen Time	WPPSI-IV VS M (SD)
At Risk/Lowest Income					
2010	59	2 – 3 hrs		2 – 3 hrs	
2014	53	2 – 3 hrs	45 – 60 min	> 3 hrs	90.11 (10.36)
Lower Middle class					
2010 (Combined with Middle Class)					
2014	74	1 – 2 hrs	15 – 30 min	2 – 3 hrs	95.12 (10.60)
Middle Class					
2010					
2014	204	1 – 2 hrs	15 – 30 min	2 – 3 hrs	95.94 (11.32)
Upper Middle Class					
2010					
2014	121	1 – 2 hrs	15 – 30 min	1 – 2 hrs	98.23 (11.10)
Total					
2010					
2014	452	1 – 2 hrs	15 – 30 min	2 – 3 hrs	95.66 (11.22)

*Note.* WPPSI-IV Visual Spatial (VS) Composite Score is derived from the Block Design and Object Assembly Subtest Scores;  $M = 100$ ,  $SD = 15$ . <sup>a</sup>Television and total screen usage time have been collapsed into time categories: 1 – 2 hours; 2 – 3 hours; > 3 hours. <sup>b</sup>Digital device usage time has been collapsed into categories: 15 – 30 minutes; 30 – 45 minutes; 45 – 60 minutes.

The means and standard deviations of the “at risk” group for reported digital device usage ( $M = 56.98$ ,  $SD = 72.62$ ) was 33 – 37 minutes more daily than the lower middle Class ( $M = 23.51$ ,  $SD = 37.60$ ), middle class ( $M = 19.24$ ,  $SD = 33.32$ ), and upper middle class ( $M = 20.98$ ,  $SD = 38.67$ ). Historically disadvantaged and poorer children are spending more time on digital devices.

Maternal education was also related to digital media usage. While the ANOVA was statistically significant, none of the individual comparisons were statistically significant and the means do not show a clear pattern. As shown in Figure 3, no clear pattern of means of smart device usage emerged as a function of maternal education. The means and standard deviations based on maternal education included those who did not graduate high school ( $M = 41.11$ ,  $SD = 51.10$ ), high school graduates ( $M = 24.32$ ,  $SD = 35.20$ ), some college ( $M = 39.44$ ,  $SD = 56.60$ ), and a college degree of higher ( $M = 21.19$ ,  $SD = 37.79$ ). See Table 4 for the time usage for each of the four groups.

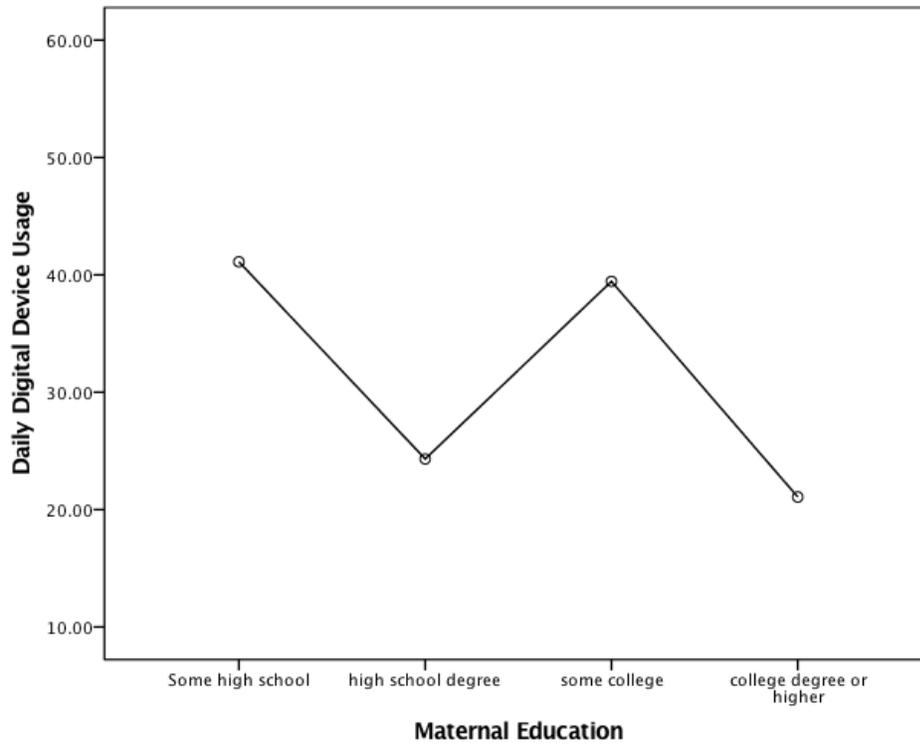


Figure 3. Digital Device Time Usage and Maternal Education

*Note:* Maternal education was also related to digital media time usage, but no clear pattern of means of smart device usage emerged as a function of maternal education.

TABLE 4  
Television Viewing Times, Smart Device Usage, and Total Screen Time in Minutes for Maternal Education Groups from the 2010 and 2014 Preschooler Groups

Maternal Education	<i>n</i>	Television Time	Digital Device Time	Total Screen Time	WPPSI-IV VS M (SD)
Did Graduate High School					
2010	10	1 – 2 hrs		1 – 2 hrs	
2014	9	1 – 2 hrs	30 – 45 min	2 – 3 hrs	92.13 (9.32)
High School Graduate					
2010	51	1 – 2 hrs		1 – 2 hrs	
2014	22	2 – 3 hrs	15 – 30 min	2 – 3 hrs	86.4 (13.43)
Some College					
2010	103	2 – 3 hrs		2 – 3 hrs	
2014	63	2 – 3 hrs	30 – 45 min	2 – 3 hrs	91.39 (9.63)
College Degree or Higher					
2010	477	1 – 2 hrs		1 – 2 hrs	
2014	352	1 – 2 hrs	15 – 30 min	1 – 2 hrs	97.11 (11.12)
Total					
2010	641	1 – 2 hrs		1 – 2 hrs	
2014	446	1 – 2 hrs	15 – 30 min	2 – 3 hrs	95.64 (11.33)

*Note.* WPPSI-IV Visual Spatial (VS) Composite Score is derived from the Block Design and Object Assembly Subtest Scores; M = 100, SD = 15. <sup>a</sup>Television and total screen usage time have been collapsed into time categories: < 1 hour; 1 – 2 hours; 2 – 3 hours; > 3 hours. <sup>b</sup>Digital device usage time has been collapsed into categories: 15 – 30 minutes; 30 – 45 minutes; 45 – 60 minutes.

*Television screen time amongst ethnic/racial and SES groups, and differing maternal education levels.* A One-way Analysis of Variance (ANOVA) was used to examine whether reported television screen time differed amongst European American, African American, Latino(a), and Asian preschoolers. There was a statistically significant effect of amount of television screen time for the different groups [ $F(3, 448) = 10.209, p < .001$ ]. The results of Games-Howell post-hoc tests indicated that European American preschoolers reported statistically significant less television viewing time usage than African American participants, but not Latino(a), and Asian participants.

Ethnic/racial identity is related to television screen time. The mean number of minutes of television viewing time reported by European American preschoolers ( $M = 94.68, SD = 60.88$ ) was almost 20 minutes less than the Asian group ( $M = 111.88, SD = 63.33$ ), about 17 minutes less than the Latino(a) group ( $M = 126.58, SD = 92.15$ ), and 30 minutes less than the African American group ( $M = 148.78, SD = 102.96$ ).

ANOVA was also used to examine whether reported television screen time differed amongst SES groups. Mean television screen time varied significantly by SES group [ $F(3, 449) = 12.447, p < .001$ ]. The results of Games-Howell post-hoc tests indicated that parents in the

upper middle class income level reported statistically significant fewer hours of television screen time than those in the three other SES groups.

The means and standard deviations of the upper middle class group for reported television viewing time ( $M = 76.98$ ,  $SD = 46.52$ ) was 30 – 60 minutes less daily than the at risk ( $M = 138.67$ ,  $SD = 94.54$ ), lower middle class ( $M = 119.53$ ,  $SD = 82.07$ ), and middle class ( $M = 106.79$ ,  $SD = 67.78$ ). Historically disadvantaged and poorer children are spending more time viewing television daily.

Maternal education was also related to television screen time [ $F(3, 443) = 4.603$ ,  $p = .003$ ]. The results of Games-Howell post-hoc tests indicated that parents with a college degree or higher ( $M = 97.96$ ,  $SD = 66.26$ ) reported statistically significant fewer hours of television screen time than those some college ( $M = 132.14$ ,  $SD = 84.93$ ). Although not statistically significant, children of parents with a college degree or higher also had less television viewing time than the high school graduate group ( $M = 121.14$ ,  $SD = 94.79$ ), and those that did not graduate high school ( $M = 106.67$ ,  $SD = 72.11$ ).

## DISCUSSION

Digital technology is easily accessible in the homes of preschoolers, and young children are spending more time with touch screen devices. Usage limits are recommended (American Academy of Pediatrics, 2015), but little guidance is provided as to what is an optimal amount. Children have added additional screen time to already existing television viewing patterns due to the ever expanding and ubiquitous nature of digital media. This study is the first to provide novel information about how the increase in digital usage relates to preschooler visual spatial functioning; that there is more screen time due to the combination of television and touch screen devices; and there are digital device usage differences based on racial identity, SES and maternal education. Additionally, the results extend previous research showing how ethnic/racial status, SES, and maternal education are related to greater risk for educational difficulties. At risk preschoolers are missing opportunities for naturally occurring visual spatial exploration within the environment because of increased integrated technology usage.

Distinguishing features of this present study included the comparison between preschoolers from 2010 with those from 2014. An examination of the life of the preschooler both before and after the explosion of integrated technology in daily life shows that overall screen time increased. This study also has important policy and guidance implications for parents and educators due to a lack of fact based recommendations for screen usage. The results lead to discussions on how to mediate the negative effect associated with digital media usage and visual spatial functioning, limiting total daily screen time in the life of the preschooler, and providing information on technological usage for at risk preschoolers.

### Digital device usage and lower visual spatial abilities

The lower WPPSI-IV Visual Spatial scores found amongst children who used touch screen digital media supports previous research indicating that two dimensional play, whether educational or not, does not translate over to the three-dimensional world (Barr, 2013). Preschoolers are spending more time daily being passive members of their environment instead

of actively exploring and developing skills. This was seen in clinical observations of the preschoolers when playing with puzzles and blocks in this study. Preschoolers with reported digital device usage often turned the puzzle pieces experimentally in all directions, but kept them at the same angle while banging the pieces together. The findings of the study support the real world observations. A review of PDMS-2 scores indicated similar deficits, even though the small number of children involved negated being able to statistically support the WPPSI-IV findings.

Children with lower amounts of reported screen time still had lower visual spatial scores than those who did not use digital technology at all. Recommending limits on digital media is not a sufficient enough measure. The findings indicate that preschoolers do not benefit from integrated technology usage. Many apps are advertised as educational, but overall WPPSI-IV IQ scores showed no increase in overall cognitive functioning that might have been gained from greater exposure to knowledge enhancing games. In fact, overall FSIQ scores were lower in children who had greater television viewing patterns and/or digital media usage. Technological play is not helping with knowledge acquisition. As mentioned, early motor development and play is linked to later STEM skills (Uttal, Meadow, Tipton, et. al., 2013). The lower visual spatial scores have long reaching implications, because later STEM performance can then be negatively impacted. Greater research is needed to determine the exact impact of this decreased visual spatial development on later STEM skills.

### Television viewing times

Television viewing times remained similar between the 2010 preschoolers and 2014 preschoolers. However, there was an addition of digital device usage on top of television viewing for the 2014 group. Children had even more total screen time on a daily basis in 2014 than 2010. This is in keeping with previous research (Rideout, 2014). Care was taken to separate television viewing from mobile device program viewing so as to accurately show how children are spending their days. The increase may be due to the ease of access to touch screen devices resulting in greater use when outside the home. Preschoolers previously had to sit at a computer to play games, which naturally resulted in time limitations. Mobile technology can now be accessed in the car, market, restaurant and other social environments. The individualized and isolative nature of digital play decreases the natural tendency of the preschooler to engage in social interactions with parents or peers, and the parent may often be on their own mobile device. The very act of socialization, and scaffolding opportunities, are lost. The child is spending more time being a passive participant watching television and playing on mobile devices, rather than being an active explorer and learner.

### Digital device usage as related to ethnic/racial, SES groups, and level of maternal education

On average, young children who are of minority status are using technology more than European American preschoolers. The results supported and built upon previous findings focusing on children who are poorer or of minority status (Rideout, 2013). Interpersonal interactions are lessened due to a lack of opportunities for socialization. Opportunities to develop visual spatial abilities are decreased. Interventions can be initiated to increase visual spatial acuity, but many

disadvantaged populations lack the means of access. At risk populations need to be informed that the seemingly positive aspects of integrated technology are, in reality, not helping small children. Policy makers, parents and educators need to be aware that just because an app is marketed as “education,” does not mean it actually is educational.

Children who are at the lowest level of SES also used technology more, indicating that those with the least amount of resources are at the most risk for lower visual spatial abilities. Technology has become affordable and is integrated into every SES level, but guiding principles for usage need to be improved.

Preschoolers whose mothers/female caregivers had a higher level of education spend less time using integrated technology daily. Maternal education appears to be linked with greater limits being placed on digital media usage. Caregivers with less education are more likely to allow greater usage of integrated technology than those with more education. As caregivers with less schooling are also more likely to be lower SES, this places an even greater need for education regarding best practices for preschoolers and screen time.

Future research should focus on integrated technology usage across different ages so as to determine if there is an appropriate age for usage. Additionally, greater information is needed on other areas of functioning, such as language development or eye movement.

## Limitations

This study has several limitations. This study was representative of American preschoolers, and exploration of children in other countries would also be beneficial. The majority of the parents/caregivers interviewed identified as white. The results should also be interpreted with caution, given the very large standard deviations of preschoolers’ use of digital devices. Greater sampling from different racial groups was desired, as well as a more stratified SES and levels of maternal education. Representations from a variety of groups would have provided more data. Parents/caregivers were surveyed for the daily patterns of the preschoolers, and their self-reported data could not be verified by independent methods, such as taping or charting daily usage. Using empirical daily monitoring would have provided more objectively verified patterns of usage. We recommend that future researchers consider ways to address these limitations and expand the knowledge of digital usage.

## CONCLUSION

Digital media usage is growing among preschoolers, and there are no proven educational or social benefits. This study can be used to inform policy and interventions for preschoolers. The two dimensional and isolative way in which touch screen devices are used does not replicate the three-dimensional world in which we live. Visual spatial exploration is key for development, and is being hampered by integrated technology usage. Additionally, preschoolers have increased overall screen time from even 8 years ago. Children who are poorer, have mothers/female caregivers with less education, or are of historically disadvantaged minority/ethnic status are on technological devices more than their peers, and are missing opportunities for developmental growth.

Education and guidance must be provided to parents so as to ensure appropriate development in children. Parents must be made aware of the real impact of usage on their children's skills acquisition. Well defined guidelines for apps that are marketed as "education" need to be developed. Educators, policy makers, mental and medical health professionals, and companies must work together to devise effective guidelines for digital media. Informed parents are more likely to develop daily routines and schedules that will support optimal development for their children and lead to greater educational success. Preschool children do not benefit from device usage, but from natural and ongoing three-dimensional play that translates into future STEM success.

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