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Toward digital participation in individuals with Autism Spectrum Disorder

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Introduction: Digital participation might have great potential for the everyday lives of individuals with Autism Spectrum Disorder (ASD). Previous research suggests that children with ASD enjoy and favor usage of digital technologies. As informative research on this topic is still sparse, this paper makes a contribution toward a better understanding of media usage in children with ASD.

Methods: Parents of 15 boys aged 6 to 11 diagnosed with ASD in Germany were asked about their children's media usage. For comparison, parents of 78 typically developing (TD) children were surveyed online.

Results: Statistical analyses reveal no differences between boys with and without ASD in media use, frequency, and reasons for use. However, there is a significant group difference in parents' perceptions of difficulty of restricting their child's media use: Parents of children with ASD reported greater difficulties of restriction of their child's media use than parents of TD children.

Discussion: Digital media is an integral part of the daily lives of children with ASD and has the potential to increase the social inclusion of people with ASD through digital participation.

KEYWORDS

Autism Spectrum Disorder, media use, digital media, digital participation, neurodevelopmental disorder

1. Introduction

Since the 1988 signature movie "Rain Man," Autism has been a popular topic in entertainment media. For example, there are some recent television series (i.e., "The Good Doctor," "The Big Bang Theory") where the main character shows the neurodiverse condition of Autism Spectrum Disorder (ASD) or a potential diagnosis is at least discussed. The protagonists with ASD are hereby often portrayed with extraordinary abilities presenting ASD in a rather favorable light (Ressa, 2022). However, ASD is classified as a serious neurodevelopmental disorder which is characterized by persistent deficits in social interaction as well as communication and by restricted, repetitive, and stereotyped patterns of behavior, interests, or activities (American Psychiatric Association, 2013). For example, persistent deficits in social interaction and communication include impairments in pragmatic language (Filipe et al., 2020). Pragmatic language can be understood as the ability to use and interpret language effectively in communicative exchanges (Milligan et al., 2007). The clinical presentation of ASD is heterogeneous, and symptoms are multifaceted and varies widely between individuals (American Psychiatric Association, 2013; Wawer and Chojnicka, 2022). For this reason, Autistic disorder, Asperger's disorder, childhood disintegrative disorder, and pervasive developmental disorder not otherwise specified in DSM-IV have been condensed into one diagnosis in DSM-V: Autism Spectrum Disorder (see Hodges et al., 2020).

The prevalence of ASD diagnoses has increased worldwide (Chiarotti and Venerosi, 2020; Bougeard et al., 2021; Zeidan et al., 2022). This increase reflects the combined effects

of, for example, a raised community awareness – which is particularly an improvement – and progress in case detection, enabled by significant improvements in early identification (Zeidan et al., 2022). A systematic literature review by Bougeard et al. (2021) shows that a prevalence of ASD ranged between 38:10,000 and 155:10,000 in European children aged 4 to 8 years in the period 2014 to 2019. Until 2012, the global estimate of ASD prevalence was 62:10,000 (Elsabbagh et al., 2012) and is nowadays estimated to have risen up to 100:10,000 (Zeidan et al., 2022). This means that approximately 1 in 100 children worldwide receives a diagnosis of ASD (Zeidan et al., 2022).

Boys have a higher prevalence of ASD than girls (Elsabbagh et al., 2012; Jiménez-Muñoz et al., 2022; Zeidan et al., 2022). In contrast to a previously reported 4:1 male-to-female ratio, a meta-analysis by Loomes et al. (2017) estimates the true male-to-female ratio to be closer to 3:1. Girls may be misdiagnosed, diagnosed later, or overlooked because of the female Autism phenotype (Hodges et al., 2020; Hull et al., 2020). "Female Autism" has been described as qualitatively different from typical "male Autism" (Hull et al., 2020). Ongoing research therefore strives to explain these sex differences while taking the possibility into account that females are better in masking symptoms which makes them less likely to receive the ASD diagnosis (for a review see Lockwood Estrin et al., 2021).

Generally, gold standard methods of diagnosing ASD typically take many hours to complete and contribute to long waiting times for concluding a diagnosis (Tariq et al., 2018). This long wait creates not only uncertainty for the entire family (Wiggins et al., 2006) but also delays the start of family support and child therapy (Tariq et al., 2018). This delay can have incremental effects as an early start of intervention has been proven to result in better developmental outcomes (Wiggins et al., 2006; Lin et al., 2022). Valid screenings administered at an early age could contribute substantially to cutting the waiting list. In many countries diagnosis of ASD is a necessary precondition for receiving treatment. A metanalysis conducted over 35 countries yielded a mean age of first diagnosis of 60.48 months (5.5 years, range: 30.90 to 234.57 months; van't Hof et al., 2021). Children with intellectual disabilities (IQ < 85) are hereby diagnosed much earlier than children without intellectual disability (IQ ≥ 85; Höfer et al., 2019). In Germany, the mean age of first diagnosis is with 78.5 months (6.5 years) already reaching school age, although most parents report already having had concerns when their child was about 2 years old (Höfer et al., 2019). The longer waiting time to be eligible for diagnostics in Germany compared to other countries highlights the need for improved forms of care for suspected cases of ASD in Germany (Höfer et al., 2019).

The authors are part of the recent grant-funded project IDEAS (Identification of Autism Spectrum Disorder using speech and facial expression recognition) which aims to develop an automated screening tool for the early detection of ASD. Since such an automated tool requires mediated input, we investigate the usefulness of various media formats to elicit relevant symptoms (Pliska et al., 2023) and aim to achieve a differentiation as selective as possible between autistic and typical development using this tool. As a necessary basis, media usage and competence in children with ASD must be compared to typically developing (TD) children to further understand usage and acceptance of digital technology in this particular group.

1.1. Media usage in individuals with ASD

"Digital technology is considered the main facilitator in social inclusion and community living in people with disabilities" (Glumbić et al., 2022, p. 98). It has been consistently reported that children with ASD are particularly attracted by digital technologies (Mazurek and Engelhardt, 2013; Laurie et al., 2019; Scholle et al., 2020), especially screen-based media and hereby namely video games. The time that children with ASD spend with digital media typically exceeds the time invested by TD peers (Krishnan et al., 2021). Several studies have shown that using media-based learning is well accepted in children with ASD (Lin et al., 2013) and in case of doubt would be preferred to other formats. For example, a study by Brunero et al. (2019) can support the preference of children with ASD – especially high-functioning boys – for digital media to support learning activities. Some authors argue that interacting with computers can be particularly enjoyed by children with ASD (Valencia et al., 2019; Arshad et al., 2020) because the digital space is perceived as a safe and trusted environment (Valencia et al., 2019). Moreover, the internet offers a virtual space largely free of face-to-face interaction, which often poses a stressful demand on individuals with ASD (Pinchevski and Peters, 2016).

1.1.1. New media for clinical diagnosis

The use of new technologies for clinical diagnostic purposes has also been discussed and investigated. For example, Alcañiz et al. (2022) successfully used an eye-tracking paradigm in a virtual environment to differentiate between children with ASD and TD children based on visual attention behaviors. Visual attention was used to measure perceiving and extracting socially relevant information. With regard to the diagnostically very relevant area of mimic expression, Forbes et al. (2016) indicate the feasibility of 2D-virtual reality (VR) in eliciting mimicry, thus confirming that participants with ASD imitate less than TD individuals when interacting with avatars. In sum, the results suggest that the behavior that people with ASD exhibit in face-to-face situations – e.g., in diagnostic settings – might be equally present when they interact with and respond to avatars (Forbes et al., 2016). This parallelism of behavior in real and virtual environments has been coined *media equation* (Reeves and Nass, 1996; Lee, 2008) and opens further potentials for the implementation of digital media in (automated) diagnostic or screening approaches.

1.1.2. New media for clinical intervention

Some authors proposed the effectiveness of new and especially immersive technology even for clinical intervention (Valentine et al., 2020; Robles et al., 2022). The term immersion describes a mediated experience in which the sense of mediation vanishes, and the experience feels as if being real (Biocca, 2002). For example, a VR system was evaluated to improve emotional skills in children with ASD (Lorenzo et al., 2016). In addition, interactions with autonomous virtual humans were successfully evaluated to help children with ASD in learning social skills (Milne et al., 2018). A systematic review by Cheng and Bololia (2023) examined whether augmented reality (AR) supports children with ASD in developing or promoting social skills. Findings suggest the effectiveness of AR e.g., for recognition of facial expressions or social reciprocity in

children with ASD (Cheng and Bololia, 2023). The use of video games as therapeutic tools in children with ASD was evaluated in a systematic review by Jiménez-Muñoz et al. (2022). The reviewed studies show that video game-based therapeutic interventions are generally effective with small effect sizes, and helpful in the development of children with ASD. For example, they show a decrease in repetitive movements after intervention with exergames in children with ASD (Jiménez-Muñoz et al., 2022). Exergames are video games that require physical movement to play (Benzing and Schmidt, 2018).

1.1.3. Media for educational purposes

Complementary or additive to intervention approaches, the use of mobile and interactive learning technologies – so-called *lean forward-media* in contrast to *lean back-media* (e.g., TV) – in the education of older children with ASD has grown impressively (Stathopoulou et al., 2020). Several studies have suggested that usage of such modern technology can facilitate learning of individuals with ASD (Valencia et al., 2019). Some interesting examples of new technology include sensors, VR, virtual agents, and AR (Valencia et al., 2019). Studies show the potential of AR to support children with ASD in school, especially for participation and learning (Hashim et al., 2021; Assis Freire de Melo et al., 2022). Finally, studies have investigated the use of technology and computer-based interventions to teach language and social skills to individuals with ASD (Grynszpan et al., 2014). The results of these investigations provide evidence for the overall effectiveness of technology-based training (Grynszpan et al., 2014). There is also good evidence that computer-based learning is both acceptable and potentially beneficial for children with ASD (Lin et al., 2013).

1.1.4. Self-selected media use and the debate of negative effects

As summarized above, technology and media have been successfully used for clinical (diagnosis and intervention) as well as educational purposes for children with ASD. Most of the authors hereby refer to the assumption that children with ASD are especially attracted to digital media but consistently refrain from evaluating this assumption. Possibly, research on this topic is still sparse because media usage and ASD research is a relatively new matter (see Stiller and Mößle, 2018), but there is a risk that the assumption has simply been nurtured by the observation of social avoidance in a population with ASD and the assumed potential for compensation through virtual environments. Despite the ubiquitous impact of media in the childhood of today's adolescents, an analysis of the literature over the past 5 years revealed limited research output addressing media use in everyday lives of individuals with ASD: one systematic review (Stiller and Mößle, 2018) and two additional studies that provide insights into the media usage of children with ASD (Lane and Radesky, 2019; Laurie et al., 2019).

Most informative is the systematic review by Stiller and Mößle (2018) on media usage by children and youths with ASD. Forty seven studies from the years 2005 to 2016 were included to determine the significance of media in the lives of these children and adolescents. Consistent across all studies, screen-based media was a preferred leisure activity of children with ASD. The most popular medium was television, followed by playing video or computer games. However, other leisure activities (e.g., outdoor play) were neglected due to the preference for screen media as a leisure activity. Compared to TD children, the studies reported mixed evidence on screen media use. However, children with ASD spent significantly less time using social media than children without ASD. Stiller and Mößle (2018) were able to identify both positive and negative effects as a result of screen media use. For example, positive effects were seen in improved social, motor, and cognitive skills, whereas negative effects manifested in less sleep, less physical activity, oppositional behavior, and problematic media use. However, as the vast majority of the reviewed studies were conducted in North America, Stiller and Mößle (2018) highlight a research gap for several European countries, including Germany, where media usage differs and is also criticized more often. In Germany, only the large-scale and regularly conducted survey Childhood, Internet, Media (*Kindheit, Internet, Medien;* KIM), which has been conducted regularly since 1999, is available. The KIM study examines the value of media in the everyday lives of a representative sample of German-speaking children (ages 6 to 13; Feierabend et al., 2021). Since 2006, the KIM study has been conducted every 2 years. However, this study reports on children in Germany in general and does not differentiate between different clinical populations, so there is no disaggregated data on children with ASD.

One of the few European-based approaches stems from Laurie et al. (2019) who report online survey data from 388 parents of children with ASD in the UK ($n = 131$), Spain ($n = 134$), and Belgium ($n = 123$). The study addresses the overarching question of how children and older individuals with ASD use technology at home. Participants were split into five groups based on the respective age ($\leq$5, 6–12, 13–17, 18–25, $\geq$26 years). The online survey–which ran for approximately 2 months in each country–collected the parent's demographics, child profiles, information about technology use at home, and attitudes toward technology use. The most commonly reported devices available were tablets and PC/laptops, whereas digital games, YouTube, listening to music, and looking at or taking photos were the most commonly reported functions of technology use already 5 years ago. The study provides evidence that adults and children with ASD were competent in the use of a wide variety of devices and interface types. In addition, the study reported that parents might be concerned about their children's use of technology, particularly the amount of time spent with devices and subsequent social consequences (Laurie et al., 2019). Regarding the specific (and already very heterogeneous) characteristics of individuals with ASD, it is important to examine media use data specifically for a population without comorbidities.

The implementations and evidence of effectiveness in diagnostics, intervention, and learning contexts described above can be seen as positive effects of media affinity in children with ASD. They exploit the potential of new technologies to adapt new offerings to the needs of individuals with ASD or to adapt existing approaches. At the same time, potential negative effects must be equally included in the analysis of media use. These have been touched upon in previous research and include problematic use of media and possible links to the intensity of autistic symptoms. Lane and Radesky (2019) hypothesize in a brief report that children

with ASD may be at higher risk for problematic media use with portable and interactive media devices. Here, problematic media use means high levels of media use that crowd out sleep, exercise, homework, or play. The authors claim that no study found a definitive connection between early media consumption and the occurrence of ASD, referring to a debate that occurs again and again in social media as well as in the scientific community, namely whether high media consumption could exacerbate or even trigger symptoms of ASD. Impetus for this debate was recently provided by a study by Dong et al. (2021) who examined the screen time of 57 TD children and 101 children with ASD in detail. Their results support previous findings that screen time was significantly longer in the group of children with ASD than in the group of TD children. In their analyses, the ASD-related symptoms became more pronounced with increasing screen time (Dong et al., 2021). Some authors use evidence such as this to claim that media exposure might even cause ASD (Slobodin et al., 2019; Dong et al., 2021). As a consequence, concern about early exposure to screen media and its potential impact on developmental delays including ASD is expressed (Heffler et al., 2022). Nevertheless, the described findings do not provide any information on the direction of a possible causal relationship, which remains unclear. Longitudinal investigations are needed such as the study by Heffler et al. (2020), who examined the association between screen media exposure and risk for diagnosed ASD or ASD-related symptoms in children at 2 years of age. Their finding among a large sample of 2,152 children was that less TV and video exposure and more interactive caregiver-child play at age 1 year were associated with fewer ASD-related symptoms at age two (Heffler et al., 2020). Nevertheless, other study results suggest that the premise of the named authors may be a fallacy since children with incipient social communication problems, such as those with ASD, simply seem to be more likely to prefer object-based play, which includes television and digital devices (Lane and Radesky, 2019). However, studies show that the symptoms of ASD are associated with high and early media use (Heffler et al., 2020; Krishnan et al., 2021). The question of a causal link or effective use of digital media to support ASD seems premature given the sparse knowledge base regarding everyday use of media in individuals with ASD. This study aims to provide insight on this topic.

1.2. Research questions and hypotheses

Our literature review indicated that research on the topic of media use in children with ASD was still sparse and data on children with ASD in Germany were missing (Stiller and Mößle, 2018). In the general population, there was an exponential increase in the use of media devices by children already during elementary school age (Spina et al., 2021), also in Germany (Feierabend et al., 2021). This was the age period in which ASD typically should already be diagnosed (van't Hof et al., 2021). A meta-analysis including 35 studies (n = 66,966 individuals with ASD) found a current mean age of 60.48 months (5.5 years) for the initial diagnosis of ASD (range: 30.90 to 234.57 months; van't Hof et al., 2021). Therefore, most children at 6 years of age and older were likely to have a valid diagnosis of ASD. Since sex differences in ASD were vast (Elsabbagh et al., 2012; Jiménez-Muñoz et al., 2022; Zeidan et al., 2022) and not yet fully understood (Hull et al., 2020), boys and girls with ASD should be considered separately. To take a further step into informing about media usage in individuals with ASD compared to TD children, we were proposing the following research question:

How does the media use of boys with ASD age 6 to 11 differ from the media use of TD boys in Germany?

Specifically, we expected (1) boys with ASD to use digital media at significantly higher rates (Dong et al., 2021; Krishnan et al., 2021). Furthermore, we assumed (2) different usage motives between boys with ASD and TD boys (e.g., Lane and Radesky, 2019). We expected that boys with ASD would be less likely to use media for social purposes than TD boys (e.g., Stiller and Mößle, 2018). We also hypothesized (3) that confidence in using digital media, enjoyment of digital media, a sense of non-mediation or *being there* while being involved with new media (so-called *presence* or *immersion*; Biocca, 2002), parents' ratings about their child's digital media behavior, and parents' perceptions of difficulty of restricting their child's media use differ between children with ASD and TD children. We expected higher scores in parents' assessments of children with ASD.

2. Method

2.1. Participants

Families with children diagnosed with ASD were recruited at an autism therapy facility in a German metropolitan area in spring 2023 in the context of a superordinate research project on the medial elicitation of ASD-associated symptoms (IDEAS). Children participated in a pilot testing to evaluate suitability of media usage formats for screening purposes. In addition, parents answered a questionnaire on media usage the results of which were reported in the current study. For the TD group, participants were recruited using an online survey through private and professional contacts via social media, e-mail distribution lists, and organizations. The target group were boys between 6 and 11 years who were enrolled in elementary school. Although ASD encompassed a wide spectrum on intellectual capacities, the study focused on age-appropriate intellectual abilities that allows comparison with TD. Recruitment resulted in a group of 15 boys with diagnosed ASD with an average age of 8.93 years (SD = 1.79). For the TD group, 78 boys at an average age of 8.21 (SD = 1.57) were included. According to the parent's report, none of the boys in both groups had an intellectual disability and none in the TD group was ever suspected of a diagnosis of ASD. Regarding socio-economic status (SES), we find higher educational levels in the TD group for both parents (see Table 1).

2.2. Measures

Data on the children's media usage were collected using an online survey for parents. This instrument included questions on the availability of media in the home, the frequency of use of these media, and individual reasons for using digital media. Parents were also asked how confident they perceive their child in using digital media, how much their child seems to enjoy it and the estimated

TABLE 1 Distribution of parents' highest educational degree.

Education degree	Father's highest level of education		Mother's highest level of education	
	ASD group ($n = 14$)	TD group ($n = 78$)	ASD group ($n = 15$)	TD group ($n = 78$)
Less than high school diploma	35.71% ($n = 5$)	19.23% ($n = 15$)	33.33% ($n = 5$)	10.26% ($n = 8$)
High school diploma	57.14% ($n = 8$)	26.92% ($n = 21$)	46.67% ($n = 7$)	24.36% ($n = 19$)
College diploma	7.14% ($n = 1$)	53.85% ($n = 42$)	20% ($n = 3$)	65.39% ($n = 51$)

degree of *immersion* (sense of non-mediation or being *there*) during usage. Finally, parents were asked whether they believe that their child spends too much time on digital media and whether they had difficulties limiting their child's media usage. For most items, a ten-point Likert scale ranging from *not at all* to *very much* was applied. Availability of media in the household was assessed by frequency of media exposure to PC/laptop, tablet, mobile phone, game console, TV, radio/podcast, digital assistants, SMART-Toys (networked toys), and others. Exposure was evaluated on an ordinal scale ranging from *never* (coded as "0"), *sometimes* (once/several times a week; coded as "1") to *often* (every/almost every day; coded as "2"). These item response options have been modified from the KIM study (Feierabend et al., 2021). In addition, reasons for using digital media were examined including: playing entertainment games, playing learning games, viewing photos, taking photos, listening to music/audiobooks/podcasts, watching movies/videos, and chatting/interacting with others and other (open space for text additions).

2.3. Data analysis

Descriptive and statistical analyses were performed using R (R Core Team, 2022, version 4.2.2). For group comparison, Mann-Whitney-U-tests were used concerning availability of media in the home (individual tests per device/application) and the children's reasons for media usage (comparison per individual activity, e.g., playing learning games, chatting...) as well as self-assessment questions to parents (all 10-point scaled). In addition, frequency responses and percentages were considered for each question. Percentage was calculated by dividing the total number of responses for a given question by the number of respondents who participated in that question. To look at possible relationships between the variables, Spearman's correlations were calculated for the 10-point scaled questions. Finally, a two (TD) to one (ASD) manual matching was performed to account for the fact that parents of TD children had higher educational attainment. The matching variables were age, father's, and mother's educational attainment. Comparisons between matched participants were also performed using Mann-Whitney-U-tests. Overall, approximate significances were calculated for datasets with sample sizes >50 and exact significances for sample sizes <50.

3. Results

Table 2 displays the availability of digital media in the home and the reported frequencies of digital media usage. Over 86% of both the ASD and TD group had access to a PC/laptop, tablet, mobile phone, TV, radio/podcast/CD player/audiobook at home. Eighty percentage in the ASD group and over 65% in the TD had a gaming console available at home. The availability of digital assistants and SMART Toys at home varied between 40% and 51% in both groups. In the ASD group ($n = 15$), 86.67% ($n = 13$), and in the TD group ($n = 78$), 87.18% ($n = 68$) had five or more than five different digital media available in the home. There was no significant difference between the two groups in the number of digital media available in the home ($p > 0.05$). Also, Mann-Whitney-U-tests revealed no differences in exposure to each digital medium between both groups ($p > 0.05$).

The children's reasons for using digital media are shown in Table 3. Most Mann-Whitney-U-tests on the individual reasons for using digital media did not reach statistical significance. Significant differences in media use were found for playing entertainment games ($p = 0.007$). The mean score for using digital media to play entertainment games was higher for children with ASD ($M = 1.67$, $SD = 0.49$, $n = 15$) than for TD children ($M = 1.14$, $SD = 0.69$, $n = 76$). According to Cohen (1988, 1992), this effect was small ($r = 0.29$).

Mann-Whitney-U-test between groups was calculated with each individual parent self-report question about their children and media (see Table 4). Here, only the variable that the parents have difficulties limiting their child's media usage became statistically significant ($U = 285$, $z = -3.20$, $p = 0.001$) with a moderate effect ($r = 0.33$). The mean score was higher for children with ASD ($M = 4.93$, $SD = 2.84$, $n = 15$) than for TD children ($M = 2.57$, $SD = 2.11$, $n = 77$).

Table 5 displays correlations between the self-assessment questions to parents about their children and media. Significant correlations were found between assessment of the child's confidence in using digital media and enjoyment of digital media usage ($p < 0.001$), as well as belief that their child spends too much time using digital media ($p = 0.028$). Furthermore, significant correlations occurred for enjoyment of digital media usage and immersion ($p < 0.001$) as well as belief that their child spends too much time using digital media ($p < 0.001$) and between the latter two ($p = 0.006$). Moreover, there was a significant correlation between belief that their child spends too much time using digital media and difficulties limiting their child's media usage ($p < 0.001$).

To control for the higher SES in the TD group, a 2:1 manual matching was performed on age, father's and mother's educational attainment (see Supplementary Table 1 for details). After the matching, the mean difference for father's educational attainment was reduced from 0.64 to 0.12 and for mothers from 0.68 to 0.56. Consequently, educational attainment of the fathers in the matched dataset no longer differs, mothers in the ASD group are still less

TABLE 2 Availability of digital media in the home and frequency of use (children with ASD: $n = 15$, TD children: $n = 78$).

Digital media	Group	Available at home	Never used	Sometimes used	Often used	*U*	*z*	*p*
PC/Laptop	ASD	93.33% ($n = 14$)	42.86% ($n = 6$)	28.57% ($n = 4$)	28.57% ($n = 4$)	403	−1.55	0.122
	TD	98.72% ($n = 77$)	60% ($n = 45$)	30.67% ($n = 23$)	9.33% ($n = 7$)			
Tablet	ASD	93.33% ($n = 14$)	0% ($n = 0$)	50% ($n = 7$)	50% ($n = 7$)	416.5	−1.13	0.26
	TD	94.87% ($n = 74$)	12.5% ($n = 9$)	48.61% ($n = 35$)	38.89% ($n = 28$)			
Mobile phone	ASD	93.33% ($n = 14$)	35.71% ($n = 5$)	28.57% ($n = 4$)	35.71% ($n = 5$)	514	−0.21	0.834
	TD	100% ($n = 78$)	27.63% ($n = 21$)	50% ($n = 38$)	22.37% ($n = 17$)			
Game console	ASD	80% ($n = 12$)	41.67% ($n = 5$)	33.33% ($n = 4$)	25% ($n = 3$)	343	−0.93	0.351
	TD	65.39% ($n = 51$)	28.57% ($n = 14$)	34.69% ($n = 17$)	36.74% ($n = 18$)			
TV	ASD	93.33% ($n = 14$)	7.14% ($n = 1$)	35.71% ($n = 5$)	57.14% ($n = 8$)	453.5	−0.21	0.832
	TD	88.46% ($n = 69$)	7.46% ($n = 5$)	38.81% ($n = 26$)	53.73% ($n = 36$)			
Radio/Podcast/CD player/Audio-books	ASD	86.67% ($n = 13$)	16.67% ($n = 2$)	58.33% ($n = 7$)	25% ($n = 3$)	386	−0.02	0.982
	TD	92.31% ($n = 72$)	28.13% ($n = 18$)	35.94% ($n = 23$)	35.94% ($n = 23$)			
Digital assistants (e.g., Alexa)	ASD	46.67% ($n = 7$)	28.57% ($n = 2$)	14.29% ($n = 1$)	57.14% ($n = 4$)	87	−1.38	0.233*
	TD	48.72% ($n = 38$)	47.22% ($n = 17$)	27.78% ($n = 10$)	25% ($n = 9$)			
SMART toys (web-connected devices)	ASD	40% ($n = 6$)	16.67% ($n = 1$)	66.67% ($n = 4$)	16.67% ($n = 1$)	66	−1.81	0.069*
	TD	51.28% ($n = 40$)	67.57% ($n = 25$)	13.51% ($n = 5$)	18.92% ($n = 7$)			

Due to individual missing values, the sample size for the frequency of digital media use data differs in part from the sample size for the availability media devices in the home. The exact sample sizes can be found in the respective columns. *Exact significance ($n < 50$).

educated than in the control group (see Supplementary Table 2 for details). Analyses with the matched sample mainly confirm the group differences reported above. However, the use of smart toys was statistically significant in the Mann-Whitney-U-test with the matched dataset ($p = 0.007$) with a strong effect ($r = 0.55$). Boys with ASD ($M = 1$, $SD = 0.63$, $n = 6$) show higher exposure to SMART Toys than TD boys ($M = 0.29$, $SD = 0.73$, $n = 14$). Significant differences in media use for playing entertainment games with a higher mean score for children with ASD (ASD: $M = 1.67$, $SD = 0.49$, $n = 15$; TD: $M = 1.24$, $SD = 0.64$, $n = 29$) was also found in the matched dataset ($p = 0.043$). This effect was moderate ($r = 0.32$). On the parent self-report question about their children and media, a statistically significant difference in parents having difficulty limiting their child's media use was also found in the matched dataset ($U = 130$, $z = -2.20$, $p = 0.027$) with a moderate effect ($r = 0.33$). The mean score in the matched dataset was also higher for children with ASD ($M = 4.93$, $SD = 2.84$, $n = 15$) than for TD children ($M = 3.03$, $SD = 2.46$, $n = 29$). The detailed results of the analyses with the matched dataset can be found in the Supplementary Tables 3–5.

4. Discussion

4.1. Group differences

The present study aimed to evaluate media usage of school-aged boys with ASD in comparison to TD boys in Germany. Therefore, we assessed the availability of digital media in the home and frequency of digital media use as well as the individual reasons for using digital media and further media use issues. An additional question surveyed a possible concern of the parents regarding their children's media usage. Our findings show that over 86% of all the participating families had five or more than five different digital media available in the home. However, the number of digital media did not differ significantly between children with ASD and TD children. This shows the growth of digital media in society (e.g.,

TABLE 3 Reasons for using digital media as named by parents across both groups (children with ASD: $n = 15$, TD children: $n = 78$).

Child uses digital media to...	Group	Never used	Sometimes used	Often used	*U*	*z*	*p*
Play entertainment games	ASD $n = 15$	0% ($n = 0$)	33.33% ($n = 5$)	66.67% ($n = 10$)	337.5	−2.72	0.007
	TD $n = 76$	17.11% ($n = 13$)	51.32% ($n = 39$)	31.58% ($n = 24$)			
Play learning games	ASD $n = 14$	0% ($n = 0$)	64.29% ($n = 9$)	35.71% ($n = 5$)	441	−1.16	0.247
	TD $n = 75$	6.67% ($n = 5$)	69.33% ($n = 52$)	24% ($n = 18$)			
View photos	ASD $n = 13$	23.08% ($n = 3$)	46.15% ($n = 6$)	30.77% ($n = 4$)	442	−0.62	0.536
	TD $n = 75$	18.67% ($n = 14$)	66.67% ($n = 50$)	14.67% ($n = 11$)			
Take photos/videos	ASD $n = 13$	15.39% ($n = 2$)	53.85% ($n = 7$)	30.77% ($n = 4$)	351	−1.78	0.076
	TD $n = 74$	28.38% ($n = 21$)	62.16% ($n = 46$)	9.46% ($n = 7$)			
Listen to music/podcasts/ audiobooks	ASD $n = 15$	13.33% ($n = 2$)	33.33% ($n = 5$)	53.33% ($n = 8$)	643.5	−0.91	0.361
	TD $n = 76$	3.95% ($n = 3$)	32.9% ($n = 25$)	63.16% ($n = 48$)			
Watch movies/videos	ASD $n = 15$	6.67% ($n = 1$)	26.67% ($n = 4$)	66.67% ($n = 10$)	435	−1.59	0.113
	TD $n = 75$	0% ($n = 0$)	60% ($n = 45$)	40% ($n = 30$)			
Chat/interact with others	ASD $n = 15$	60% ($n = 9$)	33.33% ($n = 5$)	6.67% ($n = 1$)	488.5	−0.6	0.547
	TD $n = 71$	69.01% ($n = 49$)	23.94% ($n = 17$)	7.04% ($n = 5$)			

Spina et al., 2021) and its omnipresence in the life of school-aged children independently of ASD. Children in both groups have the device categories (1) PC/laptop, (2) tablet, (3) mobile phone, (4) game console, (5) TV, (6) radio/podcast/CD player/audiobook most often available at home. This is in line with the findings of the German KIM study (Feierabend et al., 2021). However, our hypothesis that boys with ASD use digital media at significantly higher rates as was reported previously (Dong et al., 2021; Krishnan et al., 2021) could not be confirmed both in unmatched as well as matched dataset. However, in the matched dataset, children with ASD used SMART Toys at higher rates than TD children.

The observed group difference in playing entertainment games revealed a small effect in the unmatched and a moderate effect in the matched dataset, indicating a robust finding. Thus, boys with ASD are more likely to use digital media to play entertainment games than TD boys. Possibly, children with ASD prefer spending time and enjoy themselves with digital media rather than with their peers. This interpretation is supported by findings that children with ASD prefer digital media as a leisure activity over other leisure activities such as outdoor play (Stiller and Mößle, 2018). Since the survey did not specifically ask for preferences of media time over social contact, no well-founded statements can be made about this at this point. Overall, we could not show that the reasons for using media differed between the two groups. Therefore, the second hypothesis, that the usage motives differ between boys with ASD and TD boys (e.g., Lane and Radesky, 2019) could not be confirmed either.

Nevertheless, the third hypothesis could only be confirmed in parents' perceptions of difficulty of restricting their child's media use. Both, in the unmatched and the matched dataset the effect was moderate, so this finding is also robust. The other group differences were not significant. One explanation could be the high standard deviations across both groups. For example, standard deviations are highest for reported immersion and are especially high in the ASD group. Since immersion is a mediated experience in which the sense of mediation vanishes and the experience feels as if being real (Biocca, 2002), it is difficult for parents to assess this. However, parents' report of confidence in using digital media, enjoyment of digital media, parents' ratings about their child's digital media behavior, immersion, and parents' perceptions of difficulty of restricting their child's media use is higher among the ASD group.

Overall, we have no indication that ASD children use digital media more frequently and for different reasons than TD children,

TABLE 4 Parents perception of their children media usage across both groups (children with ASD: $n = 15$, TD children: $n = 78$).

Parents perception …	Group	*M (SD)*	Total: *M (SD)*	*U*	*z*	*p*
Of child's confidence in using digital media	ASD	7 (2.45)	6.45 (2.16)	492	−0.98	0.329
	TD	6.45 (2.07)				
Of child's enjoyment of digital media usage	ASD	9.53 (0.64)	8.81 (1.75)	468.5	−1.32	0.189
	TD	8.81 (1.75)				
Of child's immersion during digital media use	ASD	7.33 (3.29)	7.02 (2.72)	510	−0.72	0.472
	TD*	7.1 (2.57)				
That their child spends too much time with digital media	ASD	6.2 (2.46)	5.32 (2.61)	459.5	−1.32	0.188
	TD	5.21 (2.65)				
Of difficulty in limiting their child digital media usage	ASD	4.93 (2.84)	2.96 (2.39)	285	−3.20	0.001
	TD*	2.57 (2.11)				

The variables were assessed on a 10-point scale. *$n = 77$.

TABLE 5 Spearman's correlations.

Variable		1	2	3	4
1. Assessing the child's confidence in using digital media	*Spearman's Rho*				
	p-value				
	N				
2. Enjoyment of digital media usage	*Spearman's Rho*	0.41			
	p-value	**<0.001**			
	N	96			
3. Immersion	*Spearman's Rho*	0.04	0.39		
	p-value	0.712	**<0.001**		
	N	95	95		
4. Belief that their child spends too much time using digital media	*Spearman's Rho*	0.22	0.34	0.28	
	p-value	**0.028**	**<0.001**	**0.006**	
	N	96	96	95	
5. Difficulties limiting their child's media usage	*Spearman's Rho*	0.06	0.1	0.11	0.51
	p-value	0.575	0.348	0.315	**<0.001**
	N	95	95	94	95

The variables were assessed on a 10-point scale. Significant *p*-values are in bold.

except for playing entertainment games. Furthermore, our results also show no group differences for parents' reports regarding their child's media usage, except for parents' perceived difficulty of restricting it.

4.2. Study limitations and future research desiderates

The main limitation of the current investigation results from the difference in sample sizes–including the small size of the ASD group–and the partly large reported standardized mean differences. However, children with ASD are a vulnerable target group with a rather low prevalence: approximately 1 in 100 children worldwide has ASD (Zeidan et al., 2022). It is therefore common that recruitment of children with ASD is more difficult than that of TD children. Nevertheless, the dataset should be extended. So far, our data provide a first insight into the use of digital media in school-aged boys in Germany. The fact that there were no group differences for media exposure and reasons for digital media use, may also be a result of the chosen age range (6 to 11 years). With age, the preferences of media and consumption evolve (Feierabend

et al., 2021). Although the age range in our study was with 6 to 11 years rather large, small sample size did not allow for separating age subgroups. The sample consist of primary school children only, but we do not know about relevant differences between younger and older children. Other studies on children media usage, however, find the main age gap appearing after primary education in Germany around the age of 11 years (Ritterfeld and Lüke, 2021).

Parents in the TD group are better educated than parents in the ASD group. Recruitment did not particularly emphasize SES. As lower SES is often associated with higher media use time or possibly problematic use behavior (Nikken and Opree, 2018) group differences might at first glance be attributed to SES. However, as parents of children with ASD are also reporting higher concerns regarding and difficulties in limiting their child's media consumption, SES does not seem a valid explanation. This interpretation is confirmed by the analyses in which age and parents' educational attainment was controlled.

Another limitation lies in the method chosen. In the current investigation, we surveyed children's behavior through parents' reporting. Although a study by Wood et al. (2019) shows that parents' and children's judgments of media use were similar, parents may have had a different threshold for the questions and operationalize the values differently for themselves. This may explain some of the high standard deviations. Further studies should also collect data on how parents operationalize too much time with digital media and what they consider to be the threshold for limiting exposure. In addition, when asking whether the child spends too much time with digital media, it should be taken into account that the response might be different for parents who strongly limit their children's media use than for parents without such intention. Conversely, it could be that it is precisely those parents who apply a limitation of media time who are particularly concerned about their children's media use but did not express this due to the item wording in the present study. This could be supported by the correlation between spending too much time with digital media and difficulties in limiting digital media usage. Thus, the items may need to be expanded to include whether and to what extent the child demands time with digital media and what restrictions exist in the individual families. Active demand for the use of digital media could also be considered as an additional variable. In this context, a possible relationship between the frequency of digital media use and the difficulty of restricting should be examined in further studies. In addition, further research should explore the parent's attitudes toward digital media and ASD, e.g., when parents believe that media are the only entertainment for their child that they can provide for him or her. Parents may generally be concerned that children with or without ASD will develop problematic behaviors because of media use. For example, a study by Mazurek and Engelhardt (2013) examined the correlation between video game use and problematic behavior in boys with ASD aged 8 to 18 years. One finding was that problematic game use and role-playing game genre were significant predictors of oppositional behavior, even after controlling for age and time spent playing video games (Mazurek and Engelhardt, 2013). However, this is also debated for (apparently) TD adolescents who are the subject of media attention due to a school rampage.

Taken together and in line with the extensive literature overview, our results suggest that digital media already play an important role in everyday lives of children with ASD. Especially with the increasing use of digital media as well as the development of new media formats, media usage and effects should be continuously explored for children with ASD. Special emphasis should be given to identify formats than can support their needs and account for their disorder-driven barriers. Formats that rather enhance their symptoms should be constrained. Hereby, age is an important factor to be considered. For example, a recent study by Krishnan et al. (2021) shows that children with ASD were exposed to digital media at an earlier age compared to TD children. But it remains unclear whether this tendency is useful or harmful and what the parent's reasons for this decision might be.

4.3. Implications for digital participation in individuals with ASD

In today's world, digital media are an essential factor for social participation as even social communication is often mediated. As Glumbić et al. (2022) recently stated, the great potential of digital participation in the daily lives of people especially with ASD is evident. It is important to emphasize that individuals with ASD are not generally lacking interest in social contact, but rather feel – or are informed subliminally by their counterpart – an inability to adhere to social conventions of exchange (Begeer et al., 2008). The question arises as to what extent this can be achieved more easily in the digital space, and whether digital participation could thus function as a substitute for real-world contacts.

Social-communicative abnormalities are a core aspect of ASD-associated symptomatology. Since corresponding interactional deficits can restrict the children's participation, two possible consequences could arise for the aspect of digital participation: on the one hand, it is conceivable that the corresponding pragmatic deficits could also show up in the digital space and result in comparable interactional restrictions and possibly in exclusion or negative communication experiences. At the same time, however, some research indicates that the children find communication easier or even more successful in the digital setting, when the direct pressure of face-to-face contact is removed (Pinchevski and Peters, 2016). Further investigation of online communication by pragmatically impaired children would be desirable and could potentially have societal and even educational implications. At the same time, digital space for children should not be lightly equated with a safe space, as phenomena such as cyberbullying are unfortunately widespread.

In the introduction above, we highlighted great potential of new media for diagnostics, intervention, and education for individuals with ASD. However, we are just about to explore, develop and capitalize it. For example, mediated social interaction as provided by an avatar may not only be a suitable and economic approach in clinical or educational settings, but may even cater to the specific needs of children with ASD in overcoming typical barriers in face-to-face-interactions while communicating with others. According to the World Health Organization's International Classification of Functioning, Disability, and Health (ICF), health status (disability), body function and structure, contextual factors, and participation

are interrelated. Technologies as well as the competence in dealing with digital media as context factors play an important role in the lives of individuals with ASD (Glumbić et al., 2022). For example, Schutt (2018) demonstrated that social communication can be facilitated through digital participation. The Online Lab program applied in the study by Schutt (2018) was designed for children and adolescents aged 10 to 16 years with ASD who have trouble interacting with others, at worst with the consequence of social isolation. However, the effects of the program on the development of social and technical skills were mixed. Although young people with ASD enjoyed participating in this online program and they reported that it strengthened their relationships with others, only four out of seven participants reported improved social participation in daily life, both within and through the program. The study offers some encouragement for improving (everyday) social participation using digital tools but points to the necessity of further research. Specifically, the potential of gamification for motivation, immersion, engagement, and intervention needs to be addressed (Atherton and Cross, 2021). In addition, mobile applications have been shown to be helpful to participate for children with ASD (Wojciechowski and Al-Musawi, 2017) since they can even facilitate communication in everyday activities. For example, the mobile assistance system "Let's Play" aimed to support children with ASD in their process of learning the pronunciation and meaning of new words embedded in everyday communication (Wojciechowski and Al-Musawi, 2017). A preliminary evaluation with two children by the authors raises some hope for more efficient vocabulary learning compared to a corresponding period without the support of an assistive application (Wojciechowski and Al-Musawi, 2017).

Summarized, the presented small study provides an initial insight into the media use of boys with ASD in Germany while allowing a view into the wide field of the importance of digital media in the life of children with ASD. Our research supports findings that digital media are highly attractive to children with ASD, that they use digital media frequently, and are confident in their usage. There is no question that new media are an integral part of the daily lives of children with ASD, as well as concerning educational services, interventions, and screenings. As such, digital media and the digital environment have the potential to enhance the social inclusion of people with ASD.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by Ethics Committee, Department of Rehabilitation Sciences, Technical University Dortmund. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

LP, IN, and UR developed the concept for the present study. The literature review and most of the writing were done by LP. IN and LP collected the data. All results were computed by LP and the paper was revised by IN and UR. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fcomm.2023.1224585/full#supplementary-material

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