

Reading ebooks and printed books with parents: A case study of children with autism spectrum disorders

Autism & Developmental Language
Impairments
Volume 8: 1–17
© The Author(s) 2023
Article reuse guidelines:
sagepub.com/journals-permissions
DOI: 10.1177/23969415231168571
journals.sagepub.com/home/dli



Sung Hee Lee  and Aja McKee

Special Education, California State University Fullerton, Fullerton, CA, USA

Abstract

Background and aims: Ebooks have become a ubiquitous presence in many classrooms today. Yet, empirical evidence on literacy development has not been well produced, especially for children with autism spectrum disorder (ASD). This mixed-method case study aimed to explore how four children with ASD interact with ebooks and printed books with parents at home.

Methods: Four children (age 5–7 years) with ASD and their parents read one animated ebook and another printed book over four separate sessions. Parents also explained preselected word meanings to their children. In this mixed-method case study, we examined multiple quantitative and qualitative sources of evidence related to reading with parents at home.

Results: Quantitatively, all four children with ASD learned more word meanings from ebook than from the printed book, and three demonstrated a higher engagement with ebook than the printed book reading. Qualitatively, the majority of parents felt their children's engagement was higher with ebook than with printed book. Children with ASD tend to have tactile-related experiences while reading the printed book and auditory-related experiences during the ebook reading. Qualitative data also demonstrated a particular feature reported to be beneficial in previous research could be distracting for some children with ASD.

Implications: When parents are trained to explain critical word meanings to their children, animated ebooks can effectively improve the meaning-making skills of children with ASD. Findings also highlight the importance of individualized attention when choosing and using ebooks for children with ASD.

Keywords

Ebook, printed book, word explanation, at-home reading, autism

Introduction

Autism spectrum disorder (ASD) is a developmental disability that significantly affects communication, further contributing to reading difficulties for individuals with ASD. Although the degree of difficulty may vary from person to person, children with ASD face challenges in the area of reading comprehension and vocabulary (Nation et al., 2006). However, children with ASD develop literacy skills when given the opportunity, and animated ebooks can provide such opportunities (Smeets & Bus, 2015). Animated ebooks are an electronic version of the printed book with embedded animation. These animated

ebooks have the potential to enhance the literacy skills of children with ASD as they are known to be visual learners (Trembath et al., 2015) and have demonstrated attention to electronic screen media with an increase in verbal imitation (Shane & Albert, 2008).

Research has shown that ebooks, including animated ebooks, promote various literacy performances of typically developing children (Lee, 2017, 2020; Shamir et al., 2011; Smeets & Bus, 2015). Ebook reading with parents can also promote interaction and subsequent reading development of young children (Korat & Or, 2010; Troseth et al., 2020). Concerning children with ASD, minimal research has

Corresponding author:

Sung Hee Lee, Special Education, California State University Fullerton, Fullerton, CA 92831, USA.

Email: sunghee@fullerton.edu



Creative Commons Non Commercial CC BY-NC: This article is distributed under the terms of the Creative Commons Attribution-NonCommercial 4.0 License (<https://creativecommons.org/licenses/by-nc/4.0/>) which permits non-commercial use, reproduction and distribution of the work without further permission provided the original work is attributed as specified on the SAGE and Open Access page (<https://us.sagepub.com/en-us/nam/open-access-at-sage>).

shown that ebooks effectively improved reading comprehension of older students (Mandasari et al., 2011). Nevertheless, the current literature's major limitation is that effects of animated ebook reading with parents have not been investigated for young children with ASD. Thus, this case study explored the reading of animated ebooks with parents, in addition to added word explanation, to improve literacy performances of children with ASD, compared to the printed book reading.

Children with ASD and reading

Most children with ASD show a wide reading profile range which attributes to their oral language difficulties (Chiang & Lin, 2007; Nation et al., 2006), ranging from proficient word reading abilities (i.e., such as children with hyperlexia; Lee & Hwang, 2015) to poor reading comprehension (Chen et al., 2019; Nation et al., 2006). Making a general conclusion on ASD reading skills as a whole group is extremely difficult (Fleury et al., 2014). However, literature showed one consistent pattern of challenges in meaning making of reading, such as vocabulary and reading comprehension (Chen et al., 2019; Nation et al., 2006; Norbury & Nation, 2011). For instance, Chen et al. (2019) reported reading comprehension scores of children with ASD were lower than word reading skills regardless of their severity level.

One of the possible contributors to the poor reading comprehension of children with ASD is their lack of vocabulary. It is generally acknowledged that vocabulary, with its strong relationship with reading comprehension, is critical for successful reading performances (Baumann et al., 2003; Stahl & Fairbanks, 1986). However, research on vocabulary skills of children with ASD has been inconclusive, mainly because children with ASD showed heterogeneous vocabulary skills (Smith et al., 2007). In some studies, children with ASD showed comparable vocabulary acquisition patterns to typically developing peers (Eskes et al., 1990; Tager-Flusberg, 1985). Other studies highlighted that children with ASD show limited vocabulary (Nation et al., 2006) and their vocabulary development rates tend to be well below the expectant rate of their typically developing peers (Smith et al., 2007). Compared to peers without ASD, children with ASD also showed distinct patterns of vocabulary acquisition and use (Haebig et al., 2021; Kover et al., 2013; Volden & Lord, 1991). For instance, preverbal and verbally limited young children with ASD produced proportionally more verbs, while typical children tend to use more nouns (Haebig et al., 2021; Kover et al., 2013).

Poor vocabulary performances of children with ASD may contribute to their lack of social communication skills. While children with ASD can use language to maintain some social interaction, difficulties in social communication and interactions are reported as hallmarks of communication patterns of children with ASD (Tager-Flusberg, 1999). Considering that

vocabulary learning, like other domains of language, is heavily influenced by their interactions with others, the lack of social communication skills of children with ASD has been regarded as one of the roots of their distinct patterns of vocabulary development (Tager-Flusberg, 1985, 1999). In summary, the reading profile of children with ASD is heterogeneous in nature. Yet, children with ASD tend to have difficulties in meaning making, such as vocabulary and reading comprehension.

Shared book reading

Reading aloud to a child is one of the most valuable activities to improve various literacy skills, such as emergent literacy, vocabulary, and knowledge building (Anderson et al., 1985; Fleury et al., 2014). Shared reading as an at-home reading activity has been regarded as a major source of vocabulary development and later success in reading (Sénéchal et al., 2008; Zucker et al., 2013) through which young children increase vocabulary size via incidental exposure to a large set of new words that appear in the stories (e.g., Bus et al., 1995; Fletcher & Reese, 2005; Mol & Bus, 2011). As such, the National Reading Panel (2000) recognized such incidental vocabulary instruction as one of the best practices in improving vocabulary through which children can infer the meaning of words on their own. Additionally, vocabulary learning can be even more enhanced when adults explain word meanings as they read the story to the child (Biemiller & Boote, 2006; Bus et al., 1995).

Shared reading activity also produced positive effects, such as the improvement of on-task behavior, especially when shared book reading is appropriately adapted to support needs of children with ASD (Bellon et al., 2000; Carnahan et al., 2009). Examples of such adaptations include visual cues, music, and scaffolding strategies (Bellon et al., 2000; Carnahan et al., 2009; Mucchetti, 2013). In a recent meta-analysis, Boyle et al. (2019) analyzed 11 shared reading studies with children with ASD and found positive effects of shared reading intervention for listening comprehension. Shared reading studies were effective in other communicative (e.g., joint attention and verbal participation) and noncommunicative acts (e.g., turning pages) of children with ASD.

Concerning at-home shared reading experiences, several studies reported that parents of children with ASD provided literacy materials and engaged in literacy activities with their children with ASD in the home (Dynia et al., 2014; Lanter et al., 2012). Parents of children with ASD provided comparable amounts of literacy materials to their children as parents of children with typical development (Watson et al., 2020, as cited in Lanter et al., 2012). These parents highly valued the importance of literacy learning and read to their children with ASD at levels comparable to parents of typically developing peers (Lanter et al., 2012).

However, caregivers of children with ASD also reported their children with ASD were less engaged in shared reading activities compared to their peers without ASD, both in frequency and the duration of engagement (Dyner et al., 2014; Watson et al., 2020, as cited in Lanter et al., 2012). In short, at-home shared reading activities with parents can increase literacy performance and engagement of children with ASD.

Ebook

With rapid advancements in technology, nontraditional books or ebooks have been adopted at home and school in addition to traditional paper-printed books. The recent COVID-19 pandemic accelerated this replacement process as physical copies of books were not available due to library and school closures (Medawar & Tabet, 2020). The use of ebooks can be particularly interesting because ebooks' audio narration technology (i.e., read aloud) is analogous to the reading aloud of adults in a shared reading activity. Thus, ebooks allow a shared reading experience to be more accessible to children, especially those whose parents cannot or do not choose to read aloud to their children.

Educational benefits of ebooks on literacy have been inconclusive. A meta-analysis by Furenes et al. (2021) analyzed 39 studies and reported that printed books produced higher reading comprehension than ebooks. However, when the multimedia feature of the ebook was congruent with the storyline, the benefit of ebooks surpassed that of printed books: When the ebook provides story-related multimedia enhancement, such as an engine sound with an image of an airplane when the story is about traveling by airplane, higher story comprehension was reported from reading an ebook compared to the printed books.

Similarly, recent studies have shown ebooks, when used with interactive activities, can promote literacy performances of typically developing children (Lee, 2017, 2020; Furenes et al., 2021). For instance, a series of studies by Lee (2017, 2020) showed children can learn novel word meanings from reading an ebook, especially when the teacher briefly explains word meaning (Lee, 2017) or when a recorded word meaning explanation is provided (Lee, 2020). Additionally, ebooks with high-quality animation have been found to foster the vocabulary of typically developing children (e.g., Higgins & Cocks, 1999; Smeets & Bus, 2012). Animation requires less effort to process the meaning than static pictures (Korat & Falk, 2019). Conversely, animation incongruent with the ebook story, such as a flower blooming when the story is about an airplane, was found to distract the students' attention from the ebook (Christ et al., 2018).

The educational benefits extend to children with disabilities as well. Text to speech output of ebooks demonstrated usefulness when Boyle et al. (2021) examined use of software with a dynamic text to speech feature, and participants

with developmental disabilities showed gains in single word recognition. Caron et al. (2021) also focused on dynamic text to speech with four participants with ASD who displayed an increase in skill reading single words.

One reported benefit of the ebook concerns reading engagement or a child's attentiveness to a storybook (Moody, 2010; Roskos et al., 2012). When children's engagement was measured by their orientation time to the ebook and their spontaneous communication about the book, young children demonstrated higher engagement from reading an ebook than a printed book (Moody, 2010). Particularly, preschoolers who read the ebook version of an alphabet book showed a significantly higher engagement than those who read a printed alphabet book and a printed story book (Willoughby et al., 2015).

Concerning at-home reading, the benefit of reading ebooks with parents compared to the printed book is still inconclusive. One line of research has shown that at-home reading of an ebook with parents promoted children's literacy skills. For instance, Korat et al. (2013) showed that ebook reading with parents was as effective as reading printed books with parents. Other studies suggest that ebooks are less effective than printed books. Parish-Morris et al. (2013) reported children who read printed books with parents tend to remember better the content and the sequence of the story's events than those who read an ebook with parents. Parish-Morris and colleagues further exhibited that parents asked more story-related questions in reading the printed book than the ebook.

Ebooks for individuals with ASD. Although limited research is available, ebooks have been found to be effective in improving reading comprehension of students with ASD (Mandasari et al., 2011). Ebooks are already equipped with accommodations, such as music and visual cues, that were proven to be effective in supporting children with ASD for effective shared reading activities (Bellon et al., 2000; Carnahan et al., 2009; Mucchetti, 2013). For older elementary students with ASD, ebooks were as effective as printed books in reading comprehension (Price, 2011). Recently, Wainwright et al. (2020) compared narrative reading comprehension and engagement of children with ASD across ebook reading alone, ebook reading with adult narrative, and printed book reading. Their results showed that children with ASD showed comparable narrative reading comprehension across the three reading conditions. The children with ASD further exhibited comparable preference between the ebooks and printed books. However, children with ASD were more engaged when reading ebooks compared to the paper-book reading condition, possibly due to the interactive and multimodal features of the ebooks, suggesting that ebooks may be more effective in grasping visual attention of children with ASD.

No research has directly examined how multimodal features of ebooks function as sensory stimuli for children with ASD. Yet, when choosing ebooks for children with ASD, it

is important to consider how these sensory stimuli affect children with ASD and their interaction with educational materials. As such, accommodations to meet the sensory needs can be altered and provided as necessary. Further, accommodations are not limited simply to verbal, auditory, or visual needs. Because the environment can encompass other nuances such as relationships and emotions, tactile input, smells, cognitive needs, and kinetic experiences, accommodations can assist an individual with sensory needs, such as those with ASD.

Animated ebooks already encompass several of these multimodal features, such as verbal or auditory (e.g., auditory narration and background sounds) and visual stimuli (e.g., images and animations). Although it is still uncertain how the multimodal features change the reading behaviors of children with ASD, these sensory needs are important to keep in mind as they can impact individuals with ASD and the success they may have with materials which provide sensory input.

Purposes of the present study

Ebooks provide great benefits and potential for children with ASD as an effective at-home reading practice. In particular, multimedia aspects of ebooks, such as animation, provide ample visual support for children with ASD who are well-known to be visual learners (Trembath et al., 2015). Nevertheless, it is not clear whether using such ebook technology at home with parents can produce educational benefits for children with ASD when a simple educational activity, such as explaining word meanings to their children, is accompanied by shared reading activities. Explaining word meaning is a simple educational activity parents can easily implement without extensive training. Simply explaining word meanings has been reported to promote vocabulary learning in children with various reading abilities, both in print and electronic book reading (Biemiller & Boote, 2006; Bus et al., 1995; Lee, 2017, 2020). Additionally, the current literature has not examined parents' experiences of providing such educational activities during their shared book reading sessions with their children with ASD.

Thus, this study intends to explore: (1) How do literacy performances of children with ASD change after reading an animated ebook and a printed book with their parents' added word explanation?; (2) How do children with ASD engage with both types of book reading with parents?; and (3) What experiences do parents have providing word explanations?

To address the research questions, children with ASD read an animated ebook and a similar printed book with parents, both accompanied by parents' word explanations of important keywords that appeared in the story. The present study employed a multiple case study approach because children with ASD tend to have a wide variety of

characteristics which makes it challenging to recruit children with ASD who share similar characteristics for a large-scale study (Girolametto et al., 2007; Lenroot & Yeung, 2013). Instead, a multiple case study allows an in-depth and holistic investigation of individual-level findings. In this mixed-methods case study, we examined multiple quantitative and qualitative sources of evidence from children with ASD in the context of reading with parents at home. More specifically, the first research question was answered by examining the pretest and post-test scores of the various literacy skills of children with ASD. The second research question was answered by examining the engagement data from reading an ebook and a printed book of children with ASD, qualitatively and quantitatively. The third research question was answered by analyzing the parental interview data.

Methods

Participants

Four dyads of parent-child with ASD were recruited from Southern California. These dyads were selected because their children (a) had received a diagnosis of ASD, (b) were between 5 to 7 years old, and (c) had not read animated ebooks via TumbleBooks at the time of the recruitment. The children with ASD were addressed as Liam, Robert, Benjamin, and John (all pseudonyms). All parents identified English as their primary home language and two parents also identified speaking another language at home (Spanish and Hindi). All children received special education services in their neighborhood elementary schools. The California State University, Fullerton Institutional Review Boards (IRBs) for Protection of Human Research Subjects approved that the present research is ethically appropriate (Protocol number: HSR-18-19-635). All the children and their parents signed consent forms to agree to participate in this study.

Liam. Liam was a 6-year-old boy with what his parent described as high-functioning ASD. At age 18 months, he was diagnosed with moderate-to-severe ASD by a developmental pediatrician. His parent reported that Liam sometimes demonstrated difficulties in verbally sharing experiences with another person even though he did not have difficulties in communicating in daily conversation. Concerning reading, his parent reported that Liam could read aloud grade-level books on his preferred topic. Before his participation in the present study, Liam has read ebooks without animation.

Based on the pretest assessment described later, Liam obtained an oral expression scaled score within an average range for his age group on the BRIGANCE Comprehensive Inventory of Basic Skills-II (CIBS-II; Brigance, 2010) Oral Expression subtest. Liam's average sentences included six words or more. For reading, he

obtained an age equivalent of 5 years and 11 months on the CIBS-II Reading. In particular, Liam demonstrated skills and interests that indicate readiness for formal reading instruction, such as gaining information from books. However, he had difficulties in retelling the story from a picture book with reasonable accuracy. Liam's overall vocabulary age was equivalent to that of a child aged 4 years and 7 months on the Peabody Picture Vocabulary Test-Fourth (PPVT-4). The testing materials are described in the Materials section.

Robert. Robert was a 6-year-old boy with what his parent described as high-functioning ASD. He was diagnosed with ASD at 2 years due to a speech delay and poor social skills. At the time of the present study, Robert did not have difficulties communicating daily language and needs. His parent reported Robert had difficulties in sounding out words and demonstrated poor penmanship.

On the CIBS-II Oral Expression subtest, Robert showed an average range of oral expression scaled score for his age group: Robert could answer most wh- questions while he had some difficulties effectively sharing experiences with another person. For reading, he obtained an age equivalent of 5 years and 5 months on the CIBS-II Reading. He could not read at least five basic sight words and had difficulties in decoding words. Before his participation in the present study, Robert has not read ebooks. Robert's overall vocabulary age was equivalent to that of a child aged 2 years and 8 months on the PPVT-4.

Benjamin. Benjamin was a 7-year-old boy diagnosed with moderate-to-severe ASD, per his parent, at the age of 2 due to speech delay and poor social interaction. His parent reported that Benjamin had difficulties communicating daily needs. Benjamin had received special education services and language therapy at school and an applied behavior analysis (ABA) at home. For reading, Benjamin's parent reported that Benjamin could sound out a few basic sight words. Although he had not been exposed to ebooks with animation, he had read ebooks with static images before he participated in the present study.

On the CIBS-II Oral Expression subtest, Benjamin obtained the below range of oral expression scaled score for his age group. His parent rated his communication below average, and his typical expressive language involved three or fewer words. Although he sometimes answered who questions, Benjamin mostly did not ask or answer common wh- questions. On the CIBS-II Reading Composite Age Equivalent, Benjamin obtained an age equivalent of 5 years and 5 months. He did not recognize at least 50% of the letters and did not attempt to decode words by using word-attack skills. On the PPVT-4, Benjamin's overall vocabulary age was equivalent to that of a child aged 2 years and 8 months.

John. John was a 7-year-old boy who, according to his parent, was diagnosed with moderate-to-severe ASD at the age of 2. His expressive language was limited, and he receives special education services and speech therapy at school. John had also received ABA therapy at home, where a snack and an iPad time were used as rewards for building target behavior skills. On the CIBS-II Oral Expression subtest, John showed a below average range of oral expression scaled scores for his age group. John's average sentences were mostly three words or fewer. He did not ask or understand common wh- questions. On the CIBS-II Reading Readiness, John showed a 5 years and 5 months equivalent score (2 percentile). Before his participation in the present study, John has not read ebooks. On the PPVT-4, John's vocabulary was equivalent to that of a child aged below 2 years and 6 months.

Parents. Demographic data gathered from the parents showed an average education level of college or higher. Parents' professions were mainly skilled jobs, such as engineer and teacher (see Table 1).

Materials

Test materials. *CIBS-II.* The CIBS-II (Brigance, 2010) is a comprehensive norm-referenced standardized test for reading and mathematics for students in grades K-9. In

Table 1. Demographic data of children with ASD and parents.

| | Liam | Robert | Benjamin | John |
|---|-------------|-----------|-----------|------------|
| Gender | Male | Male | Male | Male |
| Age | 6 | 6 | 7 | 7 |
| Grade | Kinder | Kinder | 1st grade | 1st grade |
| Race | Asian | Asian | Asian | Asian |
| PPVT age equivalent | 4y7 | 3y6 | 2y8m | Below 2y6m |
| CIBS-II reading lowercase letters | 18 | 9 | 11 | 11 |
| CIBS-II readiness for reading | 13 | 8 | 8 | 7 |
| CIBS-II knows common signs | 14 | 6 | 11 | 6 |
| CIBS-II oral expression | 12 | 11 | 5 | 5 |
| CIBS-II reading composite age equivalent (percentile) | 5y11m (71%) | 5y5m (5%) | 5y5m (7%) | 5y5m (2%) |
| Education level of parent | Doctorate | College | College | College |

Note. Scaled score = has a range in value from 1 to 19 and is based on a population; 10 means average.

ASD: autism spectrum disorder; CIBS: Comprehensive Inventory of Basic Skills-II; m: months; PPVT: Peabody Picture Vocabulary Test; y, years.

the present study, the Reading composite was computed, composed of: (a) Reads Lowercase Letters, where students name lowercase letters when presented out of order; (b) Readiness for Reading where parents report a student's interest in reading, ability to read some common words, and use letter sounds to decode unfamiliar words; (c) Knows Common Signs where students read common signs (e.g., stop, go, exit); and (d) Oral Expression where students are able to express themselves in conversation.

PPVT. The PPVT-4 is a norm-referenced standardized test that measures receptive vocabulary of individuals from 2.5 years to 90 years old. In this individually administered test, the student is asked to choose one of the four pictures that best represents the meaning of the word the interviewer utters.

Pretest/Post-test vocabulary knowledge. In these individually administered tests, children were asked to choose the picture that best illustrates the target word's meaning out of a set of four pictures. Children had one practice item before the actual test items to familiarize the test format. Two experts in the field of special education reviewed the test items for content validity, and the items were pilot tested by two young children. In the post-test, identical words and illustrations were used from the pretest but with a different sequence. The same procedures were used for both the pretest and post-test administration.

Pretest/Post-test word reading. In these individual tests, children were asked to read individually presented target words. The identical words were used from the pretest but in a different order. The same procedures were used for the post-test administration.

Post-test reading comprehension. To measure reading comprehension, children were asked to answer four multiple-choice questions corresponding to the ebook and another four questions corresponding to the printed book used in the present study. Children were instructed to answer the questions by pointing the appropriate answers out of three choices (e.g., What did Abby do during recess in the story? [a] Jumping the rope; [b] Making the clay; and [c] I don't know). Children had one practice item before the actual test items to familiarize the test format. All the items were read aloud. Concerning the content validity, all the items were reviewed by the researchers who are faculty in special education and pilot tested by two young children.

Parent interview protocol. A semistructured interview was conducted individually at the end of the study via ZOOM. The interview lasted for approximately 30 to 40 min for each parent. The interview questions gauged what it was like for the participants (Seidman, 2019) when reading ebooks and printed books with their children and explaining word definitions to their children with ASD. The interview protocol is presented in Table 2, which shares the interview questions asked of the parents.

Table 2. Interview questions.

Ebook

1. Please describe your child's reactions to the ebook.
2. Were there any difficulties using this technology? If so, please explain.
3. What do you perceive were the benefits of using this technology, if any?
4. Did your child react to the animation of the ebook, if so, how?
5. Did your child's attitude toward using technology in the reading change throughout the ebook reading activity? If so, in what way?
6. Do you think using this technology affected your child's vocabulary skills? If so, how?
7. Do you think using this technology affected your child's general reading skills? If so, how?

Printed book

1. Please describe your child's reactions to reading the printed book.
2. What do you perceive were the benefits of reading a printed book with your child, if any?
3. Did your child's attitude toward reading the printed book change throughout the four sessions? If so, in what way?
4. Do you think reading the printed book with your child affected your child's vocabulary skills? If so, how?
5. Do you think reading the printed book affected your child's general reading skills? If so, how?

Word explanation

1. Were there advantages of the additional word explanation you provided, in addition to the ebook? If so, please share what these were.
 2. Were there disadvantages of the additional word explanation to the ebook? If so, please share what these were.
 3. Were there challenges to providing additional word explanation to your child during the ebook reading activity? If so, please explain.
 4. What were the advantages of the additional word explanation you provided, in addition to the printed book, if any?
 5. What were the disadvantages of the additional word explanation, if any?
- Were there challenges in providing additional word explanation, during the printed book reading activity? If so, please tell me about this.
-

Instruction materials. Storybooks. We selected an animated ebook and a printed book that present similar storylines, lengths, and word levels, written and illustrated by the same authors. All books included brightly colored illustrations that correspond to simple sentences. The ebook selected was *I Wish I Had Freckles Like Abby* (Hembrook & Heling, 2005). This animated ebook was selected from The TumbleBook Library, an online collection of ebooks for kids, for shared reading on iPads. The ebook we selected includes animated illustrations with motion, music, and background sound. Additionally, the written phrases were

highlighted as the text was narrated. The printed book selected was *I Wish I Was Tall Like Willie* (Hembrook & Heling, 2008). In this printed book, the pages have brightly colored illustrations that correspond to simple sentences.

Target words. The present study consisted of six target words selected from the ebook and another six target words from the printed book. All target words were identified as: (1) appropriate to have been acquired by typically developing 5 to 6 years old children and (2) important for story comprehension. These target words were also matched in terms of number of syllables and frequency of general word occurrence based on SUBTLEXus corpus (Brysbaert & New, 2009). The final set of words for the ebook condition included: mess, tiny, freckles, puddle, itchy, and neighbor. The target words for the printed book reading condition included: tall, pedal, reach, player, inches, and straight.

Procedures

All the sessions took place in a quiet spot in the home of children with ASD. First, all children were individually pre-tested for approximately 40 to 60 min in the BRIGANCE CBIS-II (Brigance, 2010) and the PPVT-4 (Dunn & Dunn, 2007) and in vocabulary and word reading. After the pretests, all parents were given an ebook on an iPad and a printed book. Parents were instructed to read them to their children during the next week in four different sessions (9 min and 30 s each; total 31 min). In each session, parents explained the meanings of six target words from the ebook to their children for approximately 2 min; they were given a list of words along with the suggested definition and the image of the target words. Then, the parent-child dyad listened to the ebook for about 2 min and 30 s. Parents explained another six words from the printed book to their children for about 2 min. Parents then read aloud the printed book to their child for approximately 3 min. Parents were instructed to read both types of books with their children as they normally would. These same procedures were repeated in three more sessions. Additionally, the last session was video recorded. Immediately after the last session, all children were individually post-tested for about 15 to 30 min in vocabulary, word reading, and reading comprehension. Parents were interviewed via Zoom 1 to 2 weeks after completing the reading sessions with their children.

Data analysis

Quantitative analysis of literacy performances was conducted for vocabulary, word reading, reading comprehension, and engagement. Pretest-to-posttest gains were assessed in the vocabulary and word reading subtests, while post-test scores were measured in reading comprehension. Additionally, reading engagement was assessed from the parent-child dyad reading of both types of

books during the fourth reading session that was video-recorded. Adapted from Richter and Courage (2017), engagement was calculated by visual attention by dividing the total screen or page looking time by the total story reading time. Thus, when a child shows a long time spent looking at the screen or page, it means a high level of engagement. An independent coder who was trained yet was blind to the purpose and design of the study coded the engagement. One third of the videos were rated by another independent coder, and the inter-rater reliability was over .90.

Qualitative analysis was conducted for the video-recorded session and the parental interview. Each participant's engagement was observed during their reading with an ebook and a printed book with their parents. The parental interviews were recorded via ZOOM, and the semistructured interviews were transcribed verbatim and then coded to identify themes.

Results

This section describes the literacy outcomes of four children with ASD after reading an ebook and a printed book with their parents, both with their parents' prior word explanation. The individual quantitative and qualitative data are presented, followed by the cross-case data. The detailed descriptive data are provided in Table 3.

Individual case data

Liam. Among the four participating children, Liam demonstrated the highest scores in reading readiness and vocabulary on pretests. For vocabulary, Liam showed a larger gain in learning word meanings after reading the ebook (two gain words) than the printed book reading (one gain word). For word reading, Liam read one more new word from the pretest to post-test after reading the ebook, but not after reading the printed book. Liam's comprehension score was higher after reading the ebook (75%) than the printed book (50%). Liam showed above 90% engagement in both reading conditions, while his overall engagement in reading the ebook was higher than the printed book reading. Liam also showed more utterances and gestures related to the story while reading the ebook than in the printed book.

During the reading, Liam's most relevant utterances were related to images and content of the books. Liam connected the book's content and himself by saying, "she had glasses like me," when the ebook image showed the main character wearing a pair of glasses. Liam also demonstrated active reading by stating, "I want to go back [and read again the previous page]." Another unique feature observed in Liam's reading was that Liam did not simply listen to the story reading of both types of books. Instead, he read aloud the ebook and the printed book, with mom's occasional support in sounding out difficult words.

Table 3. Frequency of literacy performances and engagement.

| Children | Categories | Variables | Ebook with vocabulary | Printed with vocabulary | | |
|-------------------------|---------------------------|---------------------------|-----------------------|-------------------------|---------|---------|
| Liam | Literacy | Vocabulary pretest | 3 (50%) | 4 (67%) | | |
| | | Vocabulary post-test | 6 (100%) | 5 (80%) | | |
| | | Vocabulary gain scores | 3 (50%) | 1 (17%) | | |
| | | Decoding pretest | 5 (83%) | 6 (100%) | | |
| | | Decoding post-test | 6 (100%) | 6 (100%) | | |
| | | Decoding gain scores | 1 (17%) | 0 (0%) | | |
| | | Comprehension post-test | 3 (75%) | 2 (50%) | | |
| | Engagement | Screen/page looking | 99% | 92% | | |
| | | Child relevant utterance | 14 | 2 | | |
| | | Parent relevant utterance | 12 | 0 | | |
| | | Child relevant gesture | 0 | 0 | | |
| | | Parent relevant gesture | 3 (50%) | 0 (0%) | | |
| | | Robert | Literacy | Vocabulary pretest | 3 (50%) | 3 (50%) |
| | | | | Vocabulary post-test | 5 (83%) | 5 (83%) |
| Vocabulary gain scores | 2 (33%) | | | 2 (33%) | | |
| Decoding pretest | 0 (0%) | | | 0 (0%) | | |
| Decoding post-test | 0 (0%) | | | 0 (0%) | | |
| Decoding gain scores | 0 (0%) | | | 0 (0%) | | |
| Comprehension post-test | 2 (50%) | | | 1 (25%) | | |
| Engagement | Screen/page looking | | 97% | 66% | | |
| | Child relevant utterance | | 0 | 0 | | |
| | Parent relevant utterance | | 0 | 0 | | |
| | Child relevant gesture | | 1 | 0 | | |
| | Parent relevant gesture | | 0 | 0 | | |
| | Benjamin | | Literacy | Vocabulary pretest | 2 (33%) | 2 (33%) |
| | | | | Vocabulary post-test | 4 (67%) | 2 (33%) |
| Vocabulary gain scores | | 2 (33%) | | 0 (0%) | | |
| Decoding | | Decoding pretest | 2 (33%) | 2 (33%) | | |
| | | Decoding post-test | 5 (83%) | 3 (50%) | | |
| | | Decoding gain scores | 3 (50%) | 1 (17%) | | |
| Comprehension | | Comprehension post-test | 0 (0%) | 0 (0%) | | |
| Engagement | | Screen/page looking | 88% | 67% | | |
| | | Child relevant utterance | 2 | 3 | | |
| | | Parent relevant utterance | 8 | 9 | | |
| | | Child relevant gesture | 0 | 0 | | |
| | | Parent relevant gesture | 0 | 0 | | |
| John | | Vocabulary | Vocabulary pretest | 1 (17%) | 1 (17%) | |
| | | | Vocabulary post-test | 3 (50%) | 2 (33%) | |
| | Vocabulary gain scores | | 2 (33%) | 1 (17%) | | |
| | Decoding | Decoding pretest | 0 (0%) | 0 (0%) | | |
| | | Decoding post-test | 0 (0%) | 0 (0%) | | |
| | | Decoding gain scores | 0 (0%) | 0 (0%) | | |
| | Comprehension | Comprehension post-test | 2 (50%) | 1 (25%) | | |
| | Engagement | Screen/page looking | 8% | 64% | | |
| | | Child relevant utterance | 0 | 1 | | |
| | | Parent relevant utterance | 0 | 1 | | |
| | | Child relevant gesture | 0 | 1 | | |
| | | Parent relevant gesture | 0 | 0 | | |

Robert. Robert had high-functioning ASD with relatively good oral language while his decoding was at an emergent reading level. On vocabulary, Robert gained two-word meanings from pretest to post-test in both ebook and printed book reading. No improvement was found for

word reading after reading the ebook and the printed book. Robert correctly answered more reading comprehension questions after reading the ebook (50%) than the printed book (25%). Robert showed higher engagement during the ebook reading than during the printed book

reading. However, Robert and his parent showed no relevant utterances and gestures during both types of book reading.

Benjamin. Benjamin had mild-to-moderate ASD and started decoding basic sight words on the pretest scores. For vocabulary, Benjamin learned two more word meanings only after reading the ebook. He also showed greater improvement in decoding after reading the ebook (three new words) than the printed book (one new word). However, Benjamin answered no reading comprehension questions (0%) in both types of book reading. Benjamin was more engaged and showed more utterances and gestures relevant to the book's story during the ebook reading than with the printed book. Comments by Benjamin's parent were mostly asking simple questions about the story or the image of the book, such as "what is it?" During the printed book reading, Benjamin's parent pointed out the word as he read the book aloud to Benjamin.

During the ebook reading, Benjamin demonstrated sensitivity to the specific background sound of the ebook. In particular, he demonstrated auditory stimming by covering his ears and making humming sounds each time he heard the water splash sound (three times from the ebook only and two times from the ebook with a word explanation).

John. John had moderate-to-severe ASD with a limited expressive language. He learned one more word meaning after the ebook (two gain words) than the printed book (one gain word) reading when the gain scores were compared. He did not recognize any new words in both book reading conditions. For reading comprehension, John correctly answered more questions after reading the ebook (50%) than after printed book reading (25%).

John's engagement was significantly lower in reading ebooks (8%) than reading the printed book (64%). Although he made nonverbal sounds and utterances, these utterances were mostly irrelevant to the story of the ebook or the printed book John read with his parent. The relevant utterance and gesture were not observed when John read both the ebook and printed book. During both the ebook and the printed reading, John sat on his parent's lap while his parent held him tightly to improve John's sitting tolerance.

Cross-case quantitative data

Cross-case analyses focused on the differences in the gains (post-test–pretest) between the ebook and the printed book reading by examining gain scores in vocabulary and gain scores in decoding. The post-test scores between the two book reading conditions were also analyzed in reading comprehension and visual attention scores.

To gain a better understanding of changes from pretest to post-test and children's post-test performances,

improvement relative to specific benchmarks was analyzed for each condition (see Table 4). Based on frequencies of participants who showed improvement, a greater number of children demonstrated gains in the number of word meanings and higher reading comprehension after reading an ebook with a prior word explanation than a printed book with a prior word explanation. For vocabulary, all four children (100%) learned at least two new word meanings after listening to the ebook while two children (Liam and Robert) learned two new words after reading a printed book. Concerning reading comprehension, three out of four children (75%) correctly answered at least two reading comprehension questions after reading an ebook. In printed book reading, one child correctly answered at least two reading comprehension questions. For word reading, one in four children decoded at least two more new words after reading an ebook, while no child met this benchmark from reading the printed book. Finally, while three in four children (75%) showed higher than 60% of engagement in reading an ebook, two of them showed an engagement higher than 80%. Concerning printed book reading, while all four children showed higher than 60% of engagement, only one child showed higher than 90% of engagement.

Qualitative data

As part of this case study, qualitative interviews were implemented. Through interviews, phenomenology was used to understand the participants' experiences with the printed text, ebook, and the word meaning explanation. The participants were also asked about how they interpreted the experiences their children had with the books and word meaning explanation. In order to attempt to capture the essence of the experience, interview questions were crafted surrounding both adult and child interactions with

Table 4. Frequencies of children who meet or exceed improvement benchmark criteria.

| | Ebook (n = 4) | Printed book (n = 4) |
|-----------------------------|------------------|-------------------------|
| Vocabulary | | |
| 2 or more new word meanings | 4 | 2 |
| 3 or more new word meanings | 1 | |
| Decoding | | |
| 2 or more new word meanings | 1 | |
| 3 or more new word meanings | | |
| Comprehension | | |
| 2 or more correct answers | 3 | 1 |
| 3 or more correct answers | 0 | 0 |
| Engagement | | |
| 60% or higher | 3 | 4 |
| 80% or higher | 3 | 1 |

the books and word meaning explanation, providing a structure to exploring the phenomena (Seidman, 2006).

Open-ended questions elicited information related to the studies' research questions. The interview data was prepared and organized for analysis, read, and coded. Coding was done using Tesch's eight steps (Creswell & Creswell, 2018) before themes emerged.

Two themes emerged from the coding of the parental interviews. These two themes were identified across the four children and their parents, with one theme having two subthemes. The first theme identified was sensory related, which explored parents identifying sensory experiences or moments of sensory input for their child with either the ebook or printed book. The second theme was engagement, which analyzed how parents viewed their child's engagement with each text (i.e., ebook or printed). The theme of sensory related had two subthemes: tactile and auditory.

Sensory related

During the interview process, parents shared sensory related experiences that their children had while reading the ebook and the printed book. The theme of sensory related encompassed any experience the child had with their senses, whether by touch, sound, or sight. This theme of sensory related included two subthemes: tactile (touch) and auditory (hearing), which parents may have interpreted their child had during any of the sessions.

Tactile. Liam's parent expressed the tactile feel of a printed book and what this experience may have meant for her son:

I think there was a little bit more engagement just because of the fact that he was physically able to hold the printed book, turn the pages easily, go back and forth between pages, if he wanted to return to a previous page to look at pictures or words... the tactile sensation... physically being able to turn the pages, go back to pages... maybe with a printed book it gives you a little different feel.

In this situation, Liam's mom felt as though being able to hold and feel the book may have increased her child's interactions with the book. Although John's mom mentioned her child's tactile experience with the printed book, she commented on him turning the pages quickly. This parent believed being able to physically hold and feel the book and flip the pages may have impacted her child in a different way. Both parents expressed that a printed text may have provided a tactile experience for their child; however, one believed the tactile experience increased engagement while the other may not have.

Auditory. Auditory experience was discussed as parents shared about their child's experience with sound or volume of the ebook. Benjamin's mom shared:

There was one part in the first book where there was a sound of a splash like water splash. I didn't realize until we were in the fourth session... that he was afraid of that sound... he didn't want to do [that book] the second and third day... he would close his eyes. So [the] third day we noticed that as soon as that part came he covers his ears.

In this experience, Benjamin did not like the water sound. As mom noted, he likes water; however, he attempted to avoid the book and covered his ears. Benjamin's mom contemplated that this was related to the pitch of the ebook sound effect and shared, "he likes water fountains, so I am not sure, it was a little more... high pitch or something."

Liam's mom also expressed her viewpoint on using audio with ebooks. She thought about how her son may be affected by someone else reading the book, and stated,

then with the option of having the audio, it allows them to actually listen to someone else reading it and maybe giving them the opportunity to comprehend more if there's someone else reading the book.

In this situation, Liam's parent believed listening to a different voice reading the story (ebook) may have allowed Liam to comprehend more of the story.

Engagement

Ebook. The second theme of engagement did not have subthemes; however, researchers aligned subthemes with whether they fell under the ebook, the printed book, or the word explanation provided to each child. Engagement looked different for each modality of book and for the word explanation. Engagement describes how the child engaged with the ebook, printed book, word explanation, and what that engagement looked like. Benjamin's parent expressed that "He was engaging more, he was more engaged for a longer time on ebooks, because of the animation and the way the ebook was presented." Robert's parent expressed a similar perspective, by saying, "I think my son is more engaged. I think he kind of thinks it's almost like a cartoon. It's even more exciting for him to watch... it was a good amount of movement."

John's parent stated something similar, sharing the engagement was due to the animation. John's mom stated, "Definitely the animation... first doing something and then probably trying to see what was being talked about... it's a good thing to try, I mean I like the idea." However, John's mom also went on to state that this was not how his engagement with the ebook started. She

posited that at first, “He was trying to go to the home page and look for other apps ... he wasn’t even following along or looking at it and he wasn’t paying attention.” Liam’s family expressed a similar sentiment about the ebook, sharing that, “It would have been nice to have the option of just having him read ... without the audio ... and that’s why I prefer him read on his own since he is able to read.” Engagement with the printed book brought about other perspectives.

Printed book. Benjamin’s parent noted the familiarity of the printed book by sharing that, “he knows he can interject ... he knows he can stop me from turning the pages before reading more ... I think it’s [a] more personal connection with me and my son.” In this example, Benjamin’s parent expressed the familiarity with the text and the personal connection. This time was the first a parent spoke about a personal connection instead of interaction with the books. John’s parent focused on engagement but noted his engagement was down with the printed book. John’s parent stated, “He tried to look at the front page and then he looks away and we try to flip pages and then he tries to go to the last page. That’s his normal reaction. He just wanted to get done with it.” Liam’s parent, on the other hand, stated she believed there was increased engagement:

I feel like [a] printed book, he seems to be a little bit more engaged with the words along with their pictures. He seems to pause more and show us an interesting page or with illustrations may point out the pictures or ask questions versus I think almost like a muscle memory with an ebook you just go through it.

Word explanation. Last, parents shared about their child’s engagement when they included word explanations that were provided to them and their child for the reading sessions. During each session, parents were provided with a list of six words along with the suggested definition and image of the words. Then, the parent and child listened to the ebook. Afterward, parents explained another six words from the printed book to their children and then read the printed book aloud. The words that were targeted for the ebook reading provided the children with a way to see the word in action. Parents identified this as supporting engagement with the ebook.

When referring to the ebook, Benjamin’s parent shared that she thought,

It would be helpful explaining the words especially because I think now he has started to recognize the static books but it’s words like running, or walking, or jumping, those kinds of actions. I mean, it’s easier to explain because of the animation. Because if I am reading a printed book, I have to imagine stuff, he has to imagine stuff, and sometimes that

gets lost in that explanation. But if something is moving on the screen, it’s easy to understand what it means.

In this example, Benjamin’s parent felt the animation of the word explanation helped with understanding the target words. Benjamin’s parent noted that this animation helped with word explanation, especially in action words, while printed books could not show you action because the pictures were static. Liam’s parent expressed a similar sentiment, and stated,

I think it definitely did help in being able to see the definition of the word ... [prior] he would read the words and know what the word is but no what the word meant, like would not be able to use it in different contexts.

Robert’s parent also felt that movement helped with engagement, and remarked,

But what I thought was like probably the best about ebooks was the movement ... especially the word droop I was having a difficult time teaching him, but because it actually droop[ed] when it said droop, it was easy.

In these excerpts, parents shared that hearing the word definition and seeing movement of the objects helped with understanding the meaning of the words and led to higher levels of engagement.

Discussion

In this multiple-case study, we examined how parent–child reading of electronic or a printed book format can change the literacy skills of young children with ASD and how added word explanation changes their reading behavior. Across the cases, most children with ASD showed a pattern of learning more word meanings and understanding better after reading an ebook with parents than reading a printed book with parents. In conjunction with the animation embedded in the ebook, the added word explanation of parents also allowed children with ASD to engage more, particularly with ebook reading.

Ebook versus printed book reading

The first aim of the present case study was to examine how children with ASD change their literacy performances by reading an animated ebook and a printed book, both accompanied by a prior word explanation by parents. Quantitatively, we found an advantage in the children’s progress following the parent–child ebook reading over the printed book reading. Both individual case data and the benchmark data showed an advantage of ebooks: all four children with ASD learned two or more new word meanings (33%) after reading an animated ebook, while

only one met the same criteria after reading a printed book. Additionally, three out of the four children met the criteria of answering two or more reading comprehension in the ebook reading activity, while only one child met the criteria in the printed book reading activity. These findings replicate the previous study that parents' ebook reading can promote young children's reading development (Korat & Or, 2010; Troseth et al., 2020). In other words, the benefit of shared book reading with parents can be extended from printed to electronic book reading and from typically developing children to children with ASD. Our findings further supported the previous research that ebooks were effective in improving the reading comprehension of older students with ASD (Mandasari et al., 2011). More broadly, the positive effect of the ebook is in line with the previous literature that technology-based learning can enhance the learning of vocabulary knowledge (Ganz et al., 2014; Xin & Leonard, 2015).

Another interesting finding from the present case study was that children who showed higher reading readiness scores tend to benefit more from the ebook reading than those with lower reading readiness scores. Liam and Robert showed higher vocabulary gain and reading comprehension scores than Benjamin and John. The engagement of Liam and Robert was also higher than the other two students. Such individual differences align with previous research that children with higher reading performances tend to learn more word meanings from reading an ebook with a prior word explanation than those with lower reading performances (Lee, 2017, 2020).

Unlike vocabulary and reading comprehension, children with ASD in the present case study did not make progress in learning to read aloud new words in either reading activity. Benchmark data showed that only Liam learned to sound out two more new words in the ebook reading activity, while no one met this benchmark in the printed book reading condition. These findings support previous findings that ebooks are ineffective in improving decoding (Zucker et al., 2009), although individual differences may exist. In short, it is encouraging that children with ASD in the present study benefited in learning vocabulary and reading comprehension from reading an ebook with parents' brief word explanation; both have shown to be the most challenged literacy areas of children with ASD (Chen et al., 2019; Nation et al., 2006; Norbury & Nation, 2011).

Engagement

The second aim of this study was to examine how children with ASD engage in an ebook and printed book reading activity with their parents, who explain the word meanings in advance. When engagement was measured based on the duration of time looking at either the iPad screen or a printed page, all but John were more engaged in reading an animated ebook than the printed book. When reading the ebook, parents also tend to engage in more verbal

interaction with their children with ASD. This behavior appeared significantly more in parents and children with high-functioning ASD dyads.

Qualitative results varied, although the majority of parents felt that engagement was higher with the ebook. Only one parent expressed increased engagement with the printed text. Our findings are consistent with previous research that preschoolers with the ebook demonstrated higher engagement than those with the printed book (Lauricella et al., 2014; Willoughby et al., 2015). The high engagement with ebooks could be due to the animation that provides visual cues to children with ASD who are known to be visual learners (Trembath et al., 2015). Given ebooks' engaging multimedia elements, the interactive sounds, voices, and animation of ebooks could capture children's attention and help them stay engaged more in reading ebooks than the print book. The novelty of such animation could also affect the higher engagement of children with ASD with ebooks than with printed books.

One unexpected finding was that John was less engaged in reading the ebook than the printed book. His low engagement in reading the ebook could be due to his poor sitting tolerance. John's parent held him during his reading so that John could stay sitting in one place. Another possibility of John's low engagement could be the novelty of an ebook might be diminished as his engagement was measured during his fourth reading of the same ebook. Although the repeated reading of the same book improves literacy performances of typically developing children (e.g., Korat, 2009; Valleley & Shriver, 2003), it is possible that John felt bored reading the same book. Finally, the parent noted that John was unfamiliar with the ebook, but was familiar with the iPad and attempted to go to the home page of the device or access applications on the device. This caused the parent to believe John's lack of understanding of the ebook format led to less engagement with the ebook.

Word explanation and animation features

The third aim of this study was to investigate parents' experiences when they provided word explanations to their children with ASD before reading both ebooks and printed books. Our findings showed positive outcomes from parents reading an animated ebook after their word explanation compared to reading a printed book after word explanation. Considering that a very similar word explanation was provided for both reading activities, an animated feature of the ebook could provide learning opportunities beyond what can be afforded by print books to encourage learning vocabulary and enhance reading comprehension.

Qualitatively, the parent interviews confirmed this finding. Three of the four parents shared they felt the ebook increased their child's understanding of the targeted

words. Parents did not find that literacy skills necessarily changed; however, they felt it was easier to teach vocabulary to their child with animation involved. The parents felt being able to see the animation of the word made a difference in word understanding, opposed to viewing the word with a static picture. The example of “droop” was used when one parent shared that she was having a challenging time describing this word, but then the animation made the object droop, making it easier to explain.

These findings are consistent with previous research demonstrating that children could learn more word meanings from listening to ebooks (Korat et al., 2014; Smeets & Bus, 2012, 2015), especially when a brief word explanation is preceded (Lee, 2017, 2020). In line with the previous study that showed animated ebooks could enhance vocabulary learning of typically developing children (e.g., Smeets & Bus, 2012), higher vocabulary learning in the ebook than in the printed book activity suggests the animation feature of the ebook might foster vocabulary learning of our participating children with ASD who are known to be visual learners (Trembath et al., 2015). These might reflect that the animation feature of the ebook supplements their difficulties in meaning making (Chen et al., 2019; Nation et al., 2006; Norbury & Nation, 2011) and bolsters the meaning-making process of these children with ASD.

It is important to note that animations used in the ebook in the present study are congruent to the story. Thus, higher vocabulary learning from the ebook than the printed book supports previous research that when the feature of the ebook is congruent with the storyline, the benefit from the ebook outperformed that of printed books (Smeets & Bus, 2015; Verhallen et al., 2006).

Another potential reason why our results favored the ebook compared to the print book reading activity in vocabulary is the novelty of the ebook’s animation feature. In line with the previous study, novelty is a potential factor of educational benefits with ebooks (Reich et al., 2019; Schomaker & Meeter, 2015). Even though two of the four children in the present study already read ebooks without animation, none read animated ebooks before participating in the present study. Thus, the novelty of animation might be important in supporting vocabulary learning of children with ASD.

Sensitivity

An interesting and unexpected finding from this case study was that some multimedia features of an animated ebook hindered one of the children, Benjamin, from engaging in reading an ebook. In the qualitative observation of his ebook reading and according to his parent’s interview, Benjamin covered his ears each time he heard a certain background sound (i.e., water splash) while he was engaged in reading a part of the ebook. Sensory sensitivities are often reported in children with ASD, with a high

prevalence of about 60 to 96% among children with ASD (Schneider & Bennetto, 2016), and auditory sensitivity is one of the most reported sensory sensitivities among children with ASD (Kuiper et al., 2019). In other words, Benjamin covered his ears because he may have received a sound, such as a water splash, as more intense or annoying due to sensory sensitivity. Benjamin’s sensitivity supports previous literature that some children with ASD tend to perceive certain sounds (e.g., loud noises) more intensively and cannot get used to certain sensory stimuli as do those without ASD (Kuiper et al., 2019; Leary & Donnellan, 2012; Robertson & Simmons, 2015). Although our observation of such individual sensitivity needs to be replicated, present study findings could suggest animated ebooks are not for all children with ASD. Children with ASD with sensory sensitivity may not benefit as much from reading an animated ebook because certain multimedia effects may hinder their literacy performance.

Implications

Findings from the present case study have several instructional implications. First, sustained efforts to involve parents meaningfully in children’s ebook reading can be achieved within the shared book reading context at home. In particular, animated ebooks can effectively improve the meaning-making skills of children with ASD, specifically when the meanings of a few critical words are provided. This embedded animation will further help children with ASD stay engaged in reading, resulting in improved literacy performances of these children with ASD.

Second, parents can be trained to explain word meanings to their children to maximize the benefit of shared ebook reading of children with ASD with parents. In the present study, parents were intentionally provided opportunities to explain word meanings to their children with ASD. Such a brief word explanation requires neither intensive training nor extensive time. Yet, this short training can help parents become more knowledgeable in how to magnify the benefits of providing an animated ebook to their children.

Third, the use of ebooks with children with ASD must consider the individual sensitivity of children with ASD. In the present study, one child with ASD demonstrated sensitivity to certain sounds from the animated ebook. Considering the wide range of characteristics and sensitivities of children with ASD (Smith et al., 2007), anyone who considers using an animated ebook with children with ASD should consider the child’s individual sensitivity to what the multimedia effects can offer.

Limitations

This study has some possible limitations that need to be considered in future research.

First, although in-depth and rich data were obtained concerning at-home experiences of reading ebooks and printed books of parents and children with ASD, the present case study has a small sample size. Future studies should replicate the present case study findings with a large group of participants in an experimental design. Second, only one example of each type of printed book and ebook was used in the present study. Even though it is challenging to identify enough samples of ebooks with animation (Korat & Falk, 2019), future research should include multiple animated ebooks. Third, in the present study, printed books were preceded by the ebook reading activities. Given that children with ASD often have short attention spans (Canitano & Scandurra, 2011), the participating children with ASD in the present study might be less engaged in reading printed books due to the order of the book presentation. Therefore, in future studies, the reading of the printed book and the reading of the ebook should be in counterbalanced order. Finally, future research should consider providing word explanation along the ebook and printed book reading activities with parents in a more naturalistic environment. In other words, parents may not be given the supplementary word list and definition to mimic more naturalistic reading condition at home with parents.

Conclusion

The findings from this case study contribute to our knowledge of the potential benefits of animated ebook reading with parents. Shared book reading with parents may be beneficial to young children with ASD and their literacy, whether the delivery medium is the traditional printed book or the increasingly popular ebook. Although individual sensitivity of children with ASD should be considered, the benefits of animated ebook reading can be enhanced in conjunction with short word meaning explanation by parents. In conclusion, through careful evaluation and design, animated ebooks have the potential to contribute to the literacy performance of young children with ASD.


Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: The research was supported by Junior/Senior Intramural Grant from California State University, Fullerton.

ORCID iD

Sung Hee Lee  <https://orcid.org/0000-0003-4784-3235>

References

- Anderson, R. C., Hiebert, E. H., Scott, J. A., & Wilkinson, I. A. G. (1985). *Becoming a nation of readers: The report of the Commission on Reading*. The National Institute of Education.
- Baumann, J. F., Edwards, E. C., Boland, E. M., Olejnik, S., & Kame'enui, E. J. (2003). Vocabulary tricks: Effects of instruction in morphology and context on fifth-grade students' ability to derive and infer word meanings. *American Educational Research Journal*, *40*(2), 447–494. <https://doi.org/10.3102/00028312040002447>
- Bellon, M. L., Ogletree, B. T., & Harn, W. E. (2000). Repeated storybook reading as a language intervention for children with autism: A case study on the application of scaffolding. *Focus on Autism and Other Developmental Disabilities*, *15*(1), 52–58. <https://doi.org/10.1177/108835760001500107>
- Biemiller, A., & Boote, C. (2006). An effective method for building meaning vocabulary in primary grades. *Journal of Educational Psychology*, *98*(1), 44–62. <https://doi.org/10.1037/0022-0663.98.1.44>
- Boyle, S., McNaughton, D., Light, J., Babb, S., & Chapin, S. E. (2021). The effects of shared e-book reading with dynamic text and speech output on the single-word reading skills of young children with developmental disabilities. *Language, Speech, and Hearing Services in Schools*, *52*(1), 426–435. https://doi.org/10.1044/2020_LSHSS-20-00009
- Boyle, S. A., McNaughton, D., & Chapin, S. E. (2019). Effects of shared reading on the early language and literacy skills of children with autism spectrum disorders: A systematic review. *Focus on Autism and Other Developmental Disabilities*, *34*(4), 205–214. <https://doi.org/10.1177/1088357619838276>
- Brigance, A. (2010). BRIGANCE® comprehensive inventory of basic skills II standardized. <https://doi.org/10.1037/t09695-000>
- Brysbart, M., & New, B. (2009). Moving beyond Kučera and Francis: A critical evaluation of current word frequency norms and the introduction of a new and improved word frequency measure for American English. *Behavior Research Methods*, *41*(4), 977–990. <https://doi.org/10.3758/BRM.41.4.977>
- Bus, A. G., Van Ijzendoorn, M. H., & Pellegrini, A. D. (1995). Joint book reading makes for success in learning to read: A meta-analysis on intergenerational transmission of literacy. *Review of Educational Research*, *65*(1), 1–21. <https://doi.org/10.3102/00346543065001001>
- Canitano, R., & Scandurra, V. (2011). Psychopharmacology in autism: An update. *Progress in Neuro-Psychopharmacology and Biological Psychiatry*, *35*(1), 18–28. <https://doi.org/10.1016/j.pnpbp.2010.10.015>
- Carnahan, C., Musti-Rao, S., & Bailey, J. (2009). Promoting active engagement in small group learning experiences for students with autism and significant learning needs. *Education and Treatment of Children*, *32*(1), 37–61. <https://doi.org/10.1353/etc.0.0047>

- Caron, J., Light, J., & McNaughton, D. (2021). Effects of a literacy feature in an augmentative and alternative communication app on single-word reading of individuals with severe autism spectrum disorders. *Research and Practice for Persons with Severe Disabilities, 46*(1), 18–34. <https://doi.org/10.1177/1540796921992123>
- Chen, L., Abrams, D. A., Rosenberg-Lee, M., Iuculano, T., Wakeman, H. N., Prathap, S., Chen, T., & Menon, V. (2019). Quantitative analysis of heterogeneity in academic achievement of children with autism. *Clinical Psychological Science, 7*(2), 362–380. <https://doi.org/10.1177/2167702618809353>
- Chiang, H. M., & Lin, Y. H. (2007). Mathematical ability of students with Asperger syndrome and high-functioning autism: A review of literature. *Autism, 11*(6), 547–556. <https://doi.org/10.1177/136236130708325>
- Christ, T., Wang, X. C., & Erdemir, E. (2018). Young children's buddy reading with multimodal app books: Reading patterns and characteristics of readers, texts, and contexts. *Early Child Development and Care, 188*(8), 1012–1030. <https://doi.org/10.1080/03004430.2016.1241776>
- Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). Sage Publications.
- Dunn, L. M., & Dunn, D. M. (2007). *Peabody picture vocabulary test* (4th ed.). Pearson.
- Dynia, J. M., Lawton, K., Logan, J. A., & Justice, L. M. (2014). Comparing emergent-literacy skills and home-literacy environment of children with autism and their peers. *Topics in Early Childhood Special Education, 34*(3), 142–153. <https://doi.org/10.1177/0271121414536784>
- Eskes, G. A., Bryson, S. E., & McCormick, T. A. (1990). Comprehension of concrete and abstract words in autistic children. *Journal of Autism and Developmental Disorders, 20*(1), 61–73. <https://doi.org/10.1007/BF02206857>
- Fletcher, K. L., & Reese, E. (2005). Picture book reading with young children: A conceptual framework. *Developmental Review, 25*(1), 64–103. <https://doi.org/10.1016/j.dr.2004.08.009>
- Fleury, V. P., Miramontez, S. H., Hudson, R. F., & Schwartz, I. S. (2014). Promoting active participation in book reading for preschoolers with autism spectrum disorder: A preliminary study. *Child Language Teaching and Therapy, 30*(3), 273–288. <https://doi.org/10.1177/0265659013514069>
- Furenes, M. I., Kucirkova, N., & Bus, A. G. (2021). A comparison of children's reading on paper versus screen: A meta-analysis. *Review of Educational Research, 91*(4), 483–517. <https://doi.org/10.3102/0034654321998074>
- Ganz, J. B., Boles, M. B., Goodwyn, F. D., & Flores, M. M. (2014). Efficacy of handheld electronic visual supports to enhance vocabulary in children with ASD. *Focus on Autism and Other Developmental Disabilities, 29*(1), 3–12. <https://doi.org/10.1177/1088357613504991>
- Girolametto, L., Sussman, F., & Weitzman, E. (2007). Using case study methods to investigate the effects of interactive intervention for children with autism spectrum disorders. *Journal of Communication Disorders, 40*(6), 470–492. <https://doi.org/10.1016/j.jcomdis.2006.11.001>
- Haebig, E., Jiménez, E., Cox, C. R., & Hills, T. T. (2021). Characterizing the early vocabulary profiles of preverbal and minimally verbal children with autism spectrum disorder. *Autism, 25*(4), 958–970. <https://doi.org/10.1177/1362361320973799>
- Hembrook, K., & Heling, D. (2005). *I wish I had freckles like Abbie [Tumblebooks]*. Raven Tree Press.
- Hembrook, K., & Heling, D. (2008). *I wish I was tall like Willie [Tumblebooks]*. Raven Tree Press.
- Higgins, N. C., & Cocks, P. (1999). The effects of animation cues on vocabulary development. *Reading Psychology, 20*(1), 1–10. <https://doi.org/10.1080/027027199278475>
- Korat, O. (2009). The effects of CD-ROM storybook reading on Israeli children's early literacy as a function of age group and repeated reading. *Education and Information Technologies, 14*(1), 39–53. <https://doi.org/10.1007/s10639-008-9063-y>
- Korat, O., & Falk, Y. (2019). Ten years after: Revisiting the question of e-book quality as early language and literacy support. *Journal of Early Childhood Literacy, 19*(2), 206–223. <https://doi.org/10.1177/1468798417712105>
- Korat, O., Levin, I., Atishkin, S., & Turgeman, M. (2014). E-book as facilitator of vocabulary acquisition: Support of adults, dynamic dictionary and static dictionary. *Reading and Writing, 27*(4), 613–629. <https://doi.org/10.1007/s11145-013-9474-z>
- Korat, O., & Or, T. (2010). How new technology influences parent—child interaction: The case of e-book reading. *First Language, 30*(2), 139–154. <https://doi.org/10.1177/0142723709359242>
- Korat, O., Shamir, A., & Heibal, S. (2013). Expanding the boundaries of shared book reading: Ebooks and printed books in parent—child reading as support for children's language. *First Language, 33*(5), 504–523. <https://doi.org/10.1177/0142723713503148>
- Kover, S. T., McDuffie, A. S., Hagerman, R. J., & Abbeduto, L. (2013). Receptive vocabulary in boys with autism spectrum disorder: Cross-sectional developmental trajectories. *Journal of Autism and Developmental Disorders, 43*(11), 2696–2709. <https://doi.org/10.1007/s10803-013-1823-x>
- Kuiper, M. W. M., Verhoeven, E. W. M., & Geurts, H. M. (2019). Stop making noise! Auditory sensitivity in adults with an autism spectrum disorder diagnosis: Physiological habituation and subjective detection thresholds. *Journal of Autism and Developmental Disorders, 49*(5), 2116–2128. <https://doi.org/10.1007/s10803-019-03890-9>
- Lanter, E., Watson, L. R., Erickson, K. A., & Freeman, D. (2012). Emergent literacy in children with autism: An exploration of developmental and contextual dynamic processes. *Language, Speech, and Hearing Services in Schools, 43*(3), 302–324. [https://doi.org/10.1044/0161-1461\(2012/10-0083\)](https://doi.org/10.1044/0161-1461(2012/10-0083))
- Lauricella, A. R., Barr, R., & Calvert, S. L. (2014). Parent—child interactions during traditional and computer storybook reading for children's comprehension: Implications for electronic storybook design. *International Journal of Child-Computer Interaction, 2*(1), 17–25. <https://doi.org/10.1016/j.ijcci.2014.07.001>
- Leary, M. R., & Donnellan, A. M. (2012). *Autism: Sensory-movement differences and diversity*. Cambridge Book Review Press.
- Lee, S. (2017). Learning vocabulary through e-book reading of young children with various reading abilities. *Reading and*

- Writing, 30(7), 1595–1616. <https://doi.org/10.1007/s11145-017-9740-6>
- Lee, S. (2020). Learning vocabulary from e-book reading and recorded word explanation for low-income elementary students with and without reading difficulties. *Reading and Writing, 33*(3), 691–717. <https://doi.org/10.1007/s11145-019-09983-2>
- Lee, S., & Hwang, M. (2015). Word and nonword processing without meaning support in Korean-speaking children with and without hyperlexia. *Reading and Writing, 28*, 217–238. <https://doi.org/10.1007/s11145-014-9522-3>
- Lenroot, R. K., & Yeung, P. K. (2013). Heterogeneity within autism spectrum disorders: What have we learned from neuroimaging studies? *Frontiers in Human Neuroscience, 7*, 1–16. <https://doi.org/10.3389/fnhum.2013.00733>
- Mandasari, V., Lu, M. V., & Theng, L. B. (2011). 2D animated social story for assisting social skills learning of children with autism spectrum disorder. In Theng, L. B. (Ed.), *Assistive and augmentive communication for the disabled: Intelligent technologies for communication, learning and teaching* (pp. 1–24). IGI Global.
- Medawar, K., & Tabet, M. (2020). Library collections and services during Covid-19: Qatar National Library experience. *Alexandria, 30*(2–3), 178–190. <https://doi.org/10.1177/0955749020986377>
- Mol, S. E., & Bus, A. G. (2011). To read or not to read: A meta-analysis of print exposure from infancy to early adulthood. *Psychological Bulletin, 137*(2), 267. <https://doi.org/10.1037/a0021890>
- Moody, A. K. (2010). Using electronic books in the classroom to enhance emergent literacy skills in young children. *Journal of Literacy and Technology, 11*(4), 22–52.
- Mucchetti, C. A. (2013). Adapted shared reading at school for minimally verbal students with autism. *Autism, 17*(3), 358–372. <https://doi.org/10.1177/1362361312470495>
- Nation, K., Clarke, P., Wright, B., & Williams, C. (2006). Patterns of reading ability in children with autism spectrum disorder. *Journal of Autism and Developmental Disorders, 36*(7), 911–919. <https://doi.org/10.1007/s10803-006-0130-1>
- National Reading Panel. (2000). *Teaching children to read: An evidence-based assessment of the scientific research literature on reading and its implications for reading instruction: Reports of the subgroups*. National Institute of Child Health and Human Development, National Institutes of Health.
- Norbury, C., & Nation, K. (2011). Understanding variability in reading comprehension in adolescents with autism spectrum disorders: Interactions with language status and decoding skill. *Scientific Studies of Reading, 15*(3), 191–210. <https://doi.org/10.1080/10888431003623553>
- Parish-Morris, J., Mahajan, N., Hirsh-Pasek, K., Golinkoff, R. M., & Collins, M. F. (2013). Once upon a time: Parent–child dialogue and storybook reading in the electronic era. *Mind, Brain, and Education, 7*(3), 200–211. <https://doi.org/10.1111/mbe.12028>
- Price, A. M. Y. (2011). Making a difference with smart tablets: Are iPads really beneficial for students with autism? *Teacher Librarian, 39*(1), 31–34.
- Reich, S. M., Yau, J. C., Xu, Y., Muskat, T., Uvalle, J., & Cannata, D. (2019). Digital or print? A comparison of preschoolers' comprehension, vocabulary, and engagement from a print book and an e-book. *AERA Open, 5*(3), 1–16. <https://doi.org/10.1177/2332858419878389>
- Richter, A., & Courage, M. L. (2017). Comparing electronic and paper storybooks for preschoolers: Attention, engagement, and recall. *Journal of Applied Developmental Psychology, 48*, 92–102. <https://doi.org/10.1016/j.appdev.2017.01.002>
- Robertson, A. E., & Simmons, D. R. (2015). The sensory experiences of adults with autism spectrum disorder: A qualitative analysis. *Perception, 44*(5), 569–586. <https://doi.org/10.1068/p7833>
- Roskos, K., Burstein, K., & You, B. K. (2012). A typology for observing children's engagement with eBooks at preschool. *Journal of Interactive Online Learning, 11*(2), 47–66.
- Schauder, K. B., & Bennetto, L. (2016). Toward an interdisciplinary understanding of sensory dysfunction in autism spectrum disorder: An integration of the neural and symptom literatures. *Frontiers in Neuroscience, 10*, 1–18. <https://doi.org/10.3389/fnins.2016.00268>
- Schomaker, J., & Meeter, M. (2015). Short-and long-lasting consequences of novelty, deviance and surprise on brain and cognition. *Neuroscience & Biobehavioral Reviews, 55*, 268–279. <https://doi.org/10.1016/j.neubiorev.2015.05.002>
- Seidman, I. (2019). *Interviewing as qualitative research: A guide for researchers in education and the social science* (5th ed.). Teachers College Press.
- Seidman, I. E. (2006). *Interviewing as qualitative research: A guide to researchers in education and the social sciences* (3rd ed.). Teachers College Press.
- Sénéchal, M., Pagan, S., Lever, R., & Ouellette, G. P. (2008). Relations among the frequency of shared reading and 4-year-old children's vocabulary, morphological and syntax comprehension, and narrative skills. *Early Education and Development, 19*(1), 27–44. <https://doi.org/10.1080/10409280701838710>
- Shamir, A., Korat, O., & Shlafer, I. (2011). The effect of activity with e-book on vocabulary and story comprehension: A comparison between kindergarteners at risk of learning disabilities and typically developing kindergarteners. *European Journal of Special Needs Education, 26*(3), 311–322. <https://doi.org/10.1080/08856257.2011.593824>
- Shane, H. C., & Albert, P. D. (2008). Electronic screen media for persons with autism spectrum disorders: Results of a survey. *Journal of Autism Developmental Disorders, 38*(8), 1499–1508. <https://doi.org/10.1007/s10803-007-0527-5>
- Smeets, D. J., & Bus, A. G. (2012). Interactive electronic storybooks for kindergartners to promote vocabulary growth. *Journal of Experimental Child Psychology, 112*(1), 36–55. <https://doi.org/10.1016/j.jecp.2011.12.003>
- Smeets, D. J., & Bus, A. G. (2015). The interactive animated e-book as a word learning device for kindergartners. *Applied Psycholinguistics, 36*(4), 899–920. [https://doi.org/10.1044/1092-4388\(2007/013\)](https://doi.org/10.1044/1092-4388(2007/013))
- Smith, V., Miranda, P., & Zaidman-Zait, A. (2007). Predictors of expressive vocabulary growth in children with autism. *Journal of Speech, Language, and Hearing Research, 50*(1), 149–160. [https://doi.org/10.1044/1092-4388\(2007/013\)](https://doi.org/10.1044/1092-4388(2007/013))

- Stahl, S. A., & Fairbanks, M. M. (1986). The effects of vocabulary instruction: A model-based meta-analysis. *Review of Educational Research, 56*(1), 72–110. <https://doi.org/10.2307/1170287>
- Tager-Flusberg, H. (1985). The conceptual basis for referential word meaning in children with autism. *Child Development, 56*(5), 1167–1178. <https://doi.org/10.2307/1130231>
- Tager-Flusberg, H. (1999). A psychological approach to understanding the social and language impairments in autism. *International Review of Psychiatry, 11*(4), 325–334. <https://doi.org/10.1080/09540269974203>
- Trembath, D., Vivanti, G., Iacono, T., & Dissanayake, C. (2015). Accurate or assumed: Visual learning in children with ASD. *Journal of Autism and Developmental Disorders, 45*(10), 3276–3287. <https://doi.org/10.1007/s10803-015-2488-4>
- Troseth, G. L., Strouse, G. A., Flores, I., Stuckelman, Z. D., & Johnson, C. R. (2020). An enhanced eBook facilitates parent–child talk during shared reading by families of low socioeconomic status. *Early Childhood Research Quarterly, 50*(Part 1), 45–58. <https://doi.org/10.1016/j.ecresq.2019.02.009>
- Valleley, R. J., & Shriver, M. D. (2003). An examination of the effects of repeated readings with secondary students. *Journal of Behavioral Education, 12*(1), 55–76. <https://doi.org/10.1023/A:1022322422324>
- Verhallen, M. J., Bus, A. G., & de Jong, M. T. (2006). The promise of multimedia stories for kindergarten children at risk. *Journal of Educational Psychology, 98*(2), 410–419. <https://doi.org/10.1037/0022-0663.98.2.410>
- Volden, J., & Lord, C. (1991). Neologisms and idiosyncratic language in autistic speakers. *Journal of Autism and Developmental Disorders, 21*(2), 109–130. <https://doi.org/10.1007/BF02284755>
- Wainwright, B. R., Allen, M. L., & Cain, K. (2020). Narrative comprehension and engagement with e-books vs. paper-books in autism spectrum condition. *Autism & Developmental Language Impairments, 5*, 1–18. <https://doi.org/10.1177/2396941520917943>
- Watson, L. R., Andrews, M. D., & Orovitz, J. (2020). *Emergent literacy in children with autism vs. typical development*. American SpeechLanguage-Hearing Association.
- Willoughby, D., Evans, M. A., & Nowak, S. (2015). Do ABC eBooks boost engagement and learning in preschoolers? An experimental study comparing eBooks with paper ABC and storybook controls. *Computers & Education, 82*, 107–117. <https://doi.org/10.1016/j.compedu.2014.11.008>
- Xin, J. F., & Leonard, D. A. (2015). Using iPads to teach communication skills of students with autism. *Journal of Autism and Developmental Disorders, 45*(12), 4154–4164. <https://doi.org/10.1007/s10803-014-2266-8>
- Zucker, T. A., Cabell, S. Q., Justice, L. M., Pentimonti, J. M., & Kaderavek, J. N. (2013). The role of frequent, interactive prekindergarten shared reading in the longitudinal development of language and literacy skills. *Developmental Psychology, 49*(8), 1425–1439. <https://doi.org/10.1037/a0030347>
- Zucker, T. A., Moody, A. K., & McKenna, M. C. (2009). The effects of electronic books on pre-kindergarten-to-grade 5 students' literacy and language outcomes: A research synthesis. *Journal of Educational Computing Research, 40*(1), 47–87. <https://doi.org/10.2190/EC.40.1.c>