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Promoting vocabulary, phonological awareness and concept about print among children at risk for learning disability: can e-books help?

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Abstract The purpose of the present study was to investigate the effect of activity with an educational electronic book (e-book), as compared with adult reading of the printed version of the same book, on the vocabulary, phonological awareness as well as concept about print of preschool children at risk for learning disabilities. The study involved the participation of 110 children aged 5–7. All participants were identified as having developmental delays placing them at risk for learning disabilities. The sample was randomly assigned to three groups: activity with the e-book, listening to the book's printed version read by an adult (reading-as-usual) and a control group. The findings indicated that the children exposed to the e-book displayed significantly higher emergent literacy improvement (vocabulary and phonological awareness) when compared with the children who participated in the other two groups. These findings and their implications are discussed.

Keywords Emergent literacy · E-book · Preschoolers at risk for LD

Introduction

Within the special needs community, children with learning disabilities (LD) represent a major segment of the population. As defined by the US National Joint Committee on Learning Disabilities (NJCLD, 2006), the term *learning disabilities* refers to a group of diverse disorders, presumably neurological in origin. Being developmental, the various manifestations of these disorders begin to appear before or during preschool (Hutinger, Beard, Bond, Johanson, & Terry, 1998; Hutinger, Bell, Daytner, & Johanson, 2005) and continue into adulthood. In addition, young

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children who evidence developmental delays in perception, memory or motor abilities may also be at risk for learning disabilities (NJCLD, 2006), the consequences of which can be observed in their difficulties with acquiring basic literacy skills such as vocabulary and phonological awareness.

Children at risk for LD often exhibit neurologically based developmental delays in perception and memory (Breznitz, 1997). The development of disorders in defined areas in the brain interferes with basic cognitive functioning such as low response rates, disrupted phonological awareness, poor short- and working memory, delayed automatic processing, perceptual problems and their self-regulation (visual, auditory and sensory) or disturbances in spatial and temporal orientation (Geary, 2004, 2009; Shaywitz, 1996; Wolf, 1991). The presence of these conditions increases the importance of incorporating multi-sensory learning, focusing on compensatory multi-sensory events (visual auditory and sensory), within any teaching program (Bulgren & Carta, 1993; Hezroni, 2004, Lipka, Lesaux, & Siegel, 2006).

Early childhood educators thus pay special attention to young children who exhibit developmental difficulties in language and emergent literacy. This reality has motivated educators to search for and construct new tools to help young children at risk for LD, including kindergarteners, to overcome their difficulties through the acquisition of fundamental reading and writing skills (NJCLD, 2006). In this spirit, the present study focused on *electronic storybooks* (digital versions of children's books generally obtainable in print format or, quite simply, "e-books", "living books" or "CD-ROM storybooks"). We asked to what extent e-books, as computerized educational tools, can contribute to the acquisition of three basic components of emergent literacy—vocabulary, phonological awareness, and concept about print (CAP)—among children at risk for LD. These three skills were chosen because children at risk for LD are known exhibit these difficulties and because acquisition of vocabulary and phonological awareness effectively predicts later success in school (Aram & Levin, 2002; Korat, Bachar, & Snapir, 2003; Sénéchal & LeFevre, 2002; Wells, 1985). The multimedia educational e-book developed by the authors indeed targets vocabulary and phonological awareness among other skills. We therefore assumed that an intervention using our e-book could be appropriately employed with this population. We tested the e-book's effectiveness for promoting the emergent literacy skills by comparing performance in two educational contexts: individual use of e-books and printed book-reading with adult support (reading-as-usual with a teacher), the reading context employed in the control group as well as the majority of kindergarten classrooms in Israel.

With the entry of computers into the kindergarten and the home, educators have been provided with new opportunities for improving learning skills in different subject areas (Snyder, 2002; Turbill, 2001; Wachob, 1993; Yelland, Hill, & Mulhearn, 2006). Research has confirmed that by engaging children in enjoyable active learning, what Underwood and Underwood (1998) call *edutainment*, computer-assisted learning promotes language and literacy development (Marsh et al., 2005; Reinking, 1997; Underwood & Underwood, 1998; Valmont, 2000) at the same time that it stimulates motivation to learn. Van Daal and Reitsma (2000) have attributed the positive learning impacts observed among children with low reading motivation and strong feelings of insecurity regarding their learning capacities to the more-structured

nature of computer-based learning (when compared to regular classroom instruction), the immediate feedback given by the computer as well as the fact that children using computer technologies become sufficiently involved to remain task-focused for greater lengths of time. With respect to children with special needs, research has indicated that computerized technologies can provide exciting and interesting experiences as well as help improve emergent literacy and writing (Lonigan et al., 2003; Margalit & Roth, 1989; Mioduser, Tur-Kaspa, & Leitner, 2000; Segers, Nooijen, & de Moor, 2006) when programmed to reflect the children's experiences and language (Howell, Erickson, Stanger, & Wheaton, 2000; Hutinger et al., 1998; Segers & Verhoeven, 2004).

A number of attempts have been made to explain the efficacy of computerized learning environments for promoting literacy skills. Eshet-Alkalai (2004) has argued that multimedia platforms are effective due to their provision of multiple representations (text, voices, pictures, and animations) of related content. Teaching with multiple representations involves the provision of mutually referring sources of information (Moreno & Duran, 2004). The related outcomes can be explained by synergy theory (Neuman, 2009) and the cognitive theory of multimedia learning (Mayer, 2003). Synergy theory (Neuman, 2009) posits that young children, but especially children at risk for reading disabilities, are more likely to improve their reading skills if they learn with a coordinated array of various types of media—computers, television, radio and printed materials such as books—as opposed to a single medium. This theory's conclusions are supported by the cognitive theory of multimedia learning (Mayer, 2003) which focuses on the combination of symbolic systems employed by the various media. Both theories reflect the contemporary child's natural environment, which is characterized by constant transitions between or simultaneous exposure to different types of media. Printed books thus transmit a story's meanings through static visual media that include text and pictures. However, when computers are used to tell stories, meaning like other narrative elements are transmitted through text and pictures with the addition of dynamic multi-sensory means such as animated visuals and auditory elements (e.g., narration, music, background voices/sounds and conversations between the characters).

Following this line of argument, we hypothesized that computer software designed to stimulate multiple cognitive functions can meaningfully contribute to the acquisition of basic emergent literacy skills by young children at risk for LD. We therefore assumed that such computer programs can provide learning events focusing on the compensatory multi-sensory activities needed by students with LD (Adams & Gathercole, 2000; Bulgren & Carta, 1993; Lipka et al., 2006). The e-book, we hoped to demonstrate, is one example of a computer tool having the potential to meet this challenge.

Just how do e-books implement these functions? Many e-books duplicate the text and illustrations of their printed versions; other e-books integrate multimedia features such as animation, music, sound effects, illuminated text and text narration (de Jong & Bus, 2003; Labbo & Kuhn, 2000; Reinking, 1997). By synchronizing the highlighting of text with the narrator's reading, e-books appear to help children keep track of the written text, behavior that may promote their understanding of the connection between print and reading. Numerous e-books also include optional

hotspots, areas on the computer screen that can be user-activated for additional information-processing. Quality e-books that contain hotspots well-coordinated with story content (also called "considerate" e-books; see Labbo & Kuhn, 2000) appear to foster children's understanding of story narrative (Lewin, 2000; Segers & Verhoeven, 2002, 2003, 2004) and improve their story recall (Underwood & Underwood, 1998) when coordinated with learning tasks (Mayer, 2003; Neuman, 2009).

Educators and researchers have therefore come to believe that the educational e-book's combination of features can effectively support children's language and literacy development (de Jong & Bus, 2003; Labbo & Kuhn, 2000; Leferver-Davis & Pearman, 2005; Neuman, 2009). In testing the validity of this view, several studies have explored the e-book's potential for enhancing verbal knowledge (Lewin, 2000; Segers & Verhoeven, 2002), including vocabulary (de Jong & Bus, 2004; Doty, Popplewell, & Byers, 2001; Shamir & Korat, 2009), and phonological awareness (Chera & Wood, 2003; Shamir, 2009; Shamir & Korat, 2007; Wise et al., 1989) and word reading (de Jong & Bus, 2002; Lewin, 2000; Wood, 2005).

E-books have also been found to enhance emergent literacy among students at risk, such as immigrants, children coming from low SES backgrounds and others lagging in language proficiency (Littleton, Wood, & Chera, 2006; McKenna & Reinking, 1997; Segers et al., 2006; Verhallen, Bus, & de Jong, 2006). For example, Verhallen et al. (2006) found that multimedia story books effectively enhanced the understanding of story line and the recall of linguistic information among kindergarten children from immigrant families who were learning Dutch as a second language. Segers et al. (2006, p. 345) have recommended that further studies be conducted to confirm the positive results obtained in their research on computerized story reading for purposes of vocabulary retention among children at risk due to physical disabilities.

Our experience with low SES students following activity with educational e-books developed by us (Shamir, 2009; Shamir & Korat, 2007) has demonstrated the technology's potential to improve emergent literacy skills such as vocabulary, phonological awareness, and CAP (Shamir, Korat, & Barbi, 2008). Another comparison of performance with an e-book as opposed to a printed version of the same book read by an adult showed similar results for low and middle SES children (Korat & Shamir, 2007). These promising findings motivated our investigation into whether e-books can likewise assist preschool children at risk for LD. Our study thus represents the first time that research with the goal of promoting emergent literacy among this specific at-risk population has been conducted.

When reviewing the literature on computer-assisted learning and children at risk, we should recall that the risk factors underlying learning problems vary considerably. Children at risk specifically for LD face neurological barriers to learning; this distinguishes them from other children at risk, such as low SES children or immigrants, groups who were denied an opportunity to learn. Some children exhibit the developmental delays indicating the risk of LD as early as kindergarten (NJCLD, 2006). Due to the variety of factors contributing to risk and its appearance, we could not assume that the findings of research conducted among different at-risk groups

were fully comparable. We were uncertain, for example, as to whether the vocabulary assistance given in previous research would be as effective for children at risk for LD as it was for low and middle SES preschoolers (see for example Shamir et al., 2008). In addition, we could not be sure that experience with phonological awareness activations would improve this skill, which has been recognized as especially problematic for young children at risk for LD (Adams & Gathercole, 2000; Hutinger et al., 2005; Lipka et al., 2006; Most, Al-Yagon, Tur-Kaspa & Margalit, 2000).

Since children are introduced to the world of written language and literacy primarily during joint adult-child reading of books (Bus, van Ijzendoorn, & Pellegrini, 1995; Ninio, 1980; Sénéchal, 2006; Snow & Ninio, 1986), we were especially interested in comparing two educational contexts aimed at promoting emergent literacy: children independently reading an e-book and an adult reading a printed book to children in the standard kindergarten setting (reading-as-usual). A careful comparison of performance in these two settings is needed because children at risk for LD, due to their impaired perception and limited short-term memory (Adams & Gathercole, 2000; Lipka et al., 2006), may need more adult support as well as more multi-sensory learning activities, shown to be crucial for compensating deficiencies than do typically developing children (Bulgren & Carta, 1993; NJCLD, 2006). Such comparisons are also required to ascertain which conditions are pedagogically more appropriate for the acquisition of specific emergent literacy skills (Glasgow, 1996; Matthew, 1997; Reinking, 1997) by children at risk for LD.

Although the literature consistently points to the benefits of e-books in promoting literacy among typically developing children, some researchers have reported inconsistent results after comparing emergent literacy performance following a child's independent reading of an e-book with listening to an adult reading a printed version of the same book (de Jong & Bus, 2002, 2004; Korat & Shamir, 2007; Segers, Takke, & Verhoeven, 2004; Wood, 2005). We suggest that these inconsistencies may have been products of the different study designs, materials, age groups, and other participants' characteristics in addition to variation in the e-books' positive educational quality (de Jong & Bus, 2003; Korat & Shamir, 2004; Shamir & Korat, 2006). Many commercial e-books do not include important features such as highlighting entire sentences as well as separate words, a dictionary option, or hotspots that can be activated only after the text has been read. They also rarely contain functions allowing children to see and hear how words taken from the text can be divided into their component sounds, exposure necessary for phonological awareness.

Returning to the study reported here, our investigation focused on the effectiveness of a specially constructed educational e-book designed by us to foster emergent literacy among young children with diverse academic needs. In keeping with the concept of edutainment, we included three different modes in our CD-ROM storybook—"read story only", "read story with dictionary", and "read story and play"—each of which could be activated separately. These modes, in addition to other characteristics, were developed to focus on vocabulary, phonological awareness, and text tracking (the highlighting and coloring of printed text as it is narrated). To avoid distraction from the reading task caused by the activation of hotspots extraneous to the learning task, we programmed the hotspots to appear only

after the narrator had completed his reading of the page's text. This decision was based on the assumption that most of the children would have completed reading the text at about the same time. Hence, previous research, together with the careful planning of our e-book encouraged us to test whether the same tool found supporting emergent literacy in other at risk as well as typically developing children might provide some response to the learning difficulties faced by children at risk for LD (Al-Yagon, 2003; Hezroni, 2004; Swanson, Harris, & Graham, 2003).

The purpose of the current study was, therefore, to compare the e-book's effectiveness for promoting emergent literacy among preschoolers at risk for LD in two educational contexts: individual use of e-books as opposed to children listening to an adult reading a printed book (reading-as-usual). We chose the reading-as-usual approach for the test situation because this setup best reflects what happens in the typical preschool classroom.

Given our objectives, we chose to investigate three emergent literacy features—phonological awareness, vocabulary, and CAP—each of which has high predictive value regarding future academic success. We hypothesized that the e-book's dictionary (designed for vocabulary development) and read and play modes (for phonological awareness) would support learning because they permit multiple activations of multi-sensory (auditory and visual) learning platforms (Neuman, 2009). Although CAP was not directly targeted by the e-book, we hypothesized that exposure to e-book reading would help improve book orientation skills at a level comparable to that achieved by exposure to printed books (see Clay, 1989; Whitehurst & Lonigan, 2001). We also assumed that the opportunity to activate hotspots supporting vocabulary and phonological awareness within the context of e-book reading would provide a more authentic and enjoyable—and thus more effective—learning tool for these children.

The research questions were consequently formulated as follows: (1) To what extent does e-book activity foster improvement in emergent literacy performance among preschoolers at risk for LD? (2) In which areas of emergent literacy—vocabulary, phonological awareness, or CAP—will the research subjects show greater improvement, and to what extent, following e-book activity? and (3) To what extent will literacy improvement vary as a function of the context to which the children are exposed (e-book activity versus reading a printed book versus no targeted reading activity)?

Method

Participants

Altogether, 110 kindergarteners aged 5–7 ($M = 72.13$; SD = 5.7, in months; 69 boys (62.7%) and 41 girls (37.3%)), participated in the study (see Table 1). The participants were selected as follows: First we contacted kindergartens located in middle SES neighborhoods in Israel having classes with children who had been independently identified by the Ministry of Education's Educational Psychological

Table 1 Participants' characteristics per group

	E-book			Printed book			Comparison group		
	N	%	SD	*N*	%	SD	*N*	%	SD
Gender									
Boys	25	59.5		22	64.7		22	64.7	.30
Girls	17	40.5		12	35.3		12	35.3	
Age									
5–6	14	33.3		18	52.9		20	58.8	5.53
6–7	28	66.7		16	47.1		14	41.2	
KABC verbal	42	5.405	1.018	34	5.382	.946	34	5.418	.893
KABC non-verbal	42	6.843	1.349	34	6.671	1.037	34	6.754	1.334

Services as being at risk for learning disabilities. These evaluations had been performed by means of a comprehensive psycho-educational assessment test.

Israel's Ministry of Education, like educational authorities in other countries, maintains strict confidentiality regarding the results of standardized diagnostic tests. We, like other researchers in the area of learning disabilities, were therefore prevented from making quantified comparisons and publishing the results (Al-Yagon, 2003, 2007). The subjects' young age and the school's fear of labeling the children apparently present barriers to the accurate diagnosis of the specific type of learning disability (Costenbader, Rohrer, & DiFonzo, 2000). Many countries throughout the world therefore delay categorization until first grade. Israel's Ministry of Education, for example, has adopted a policy of classifying young children with developmental delays as being at risk for learning disabilities in preference to specifying the particular disability (Margalit, 2000). In dealing with these constraints, four criteria were constructed for recruiting individual participants: (1) They had been diagnosed as having developmental delays placing them at risk for LD; (2) They did not evidence other potential causes of learning problems, such as low general intelligence (an IQ less than 80) and sensory or emotional impairment, criteria dictated by the neurological basis of LD (NJCLD, 2006); (3) They were Hebrew speakers; and (4) Non verbal and verbal ability tests had confirmed that all the participants complied with the definition of populations at risk for learning disabilities, that is, they exhibited lower verbal than non-verbal ability (NJCLD, 2006).

Following selection of the participants, the sample was randomly assigned to three groups: In the first intervention group ($n = 42$), children activated the e-book; in the second intervention group ($n = 34$), children heard the same story read from a printed book by an adult; while in the third group ($n = 34$), the control group, children participated in the regular kindergarten program. All the participants had previously acquired some preliminary experience with computers as part of the regular class curriculum. Children in the control group did not receive the structured intervention (i.e., neither the e-book activity nor the printed version of e-book story).

Children's cognitive level

In order to select a sufficiently uniform sample, cognitive level (verbal and non verbal) was assessed using two subtests taken from the Kaufman Assessment Battery for Children (KABC) (Kaufman & Kaufman, 1983), which is commonly used in Israel's kindergartens for research purposes (see Table 1). This standardized test can be administered to assess the intelligence of subjects ranging in age from 2.5 years through adulthood. In the current study, the three children who earned scores less than two standard deviations below the mean in one of the two subtests were excluded from the study.

Verbal ability (KABC antonyms subtest)

Eighteen common Hebrew words comprised this subtest. The children were asked to provide the antonyms for each of the words mentioned. Prior to testing, they practiced a sample item, which was followed by corrective feedback and explanations. Scoring: Each correct answer was scored 1; total scores ranged from 0 to 18. This subtest's reliability was relatively high ($\alpha = .83$) when compared to the reliability of other parts of the battery appropriate for preschoolers.

Non verbal intelligence (KABC parallels subtest)

This test examines a child's ability to select the picture or form most appropriate for completing 2×2 visual parallels. During the test, the experimenter presented cards showing visual parallels in which one element is missing. The child was then asked to choose the picture or form that best completed the original relationship. For example, a child might be presented with a picture of a carrot and a rabbit; underneath would be a picture of a bone and an empty square, followed by these instructions: "This picture (the experimenter points to the carrot) fits this picture (while pointing to the rabbit) just like this picture (pointing to the bone) fits one of these pictures (while pointing to 6 alternatives). Which picture would you choose?" The test included 19 items, in increasing order of difficulty, with the first 4 items meant to clarify the concept parallelism; children under the age of 7 were tested on the first 13 items only. In our study, a score of one was given for each picture properly identified by the child; total score range: 0–13. The test's reliability score was $\alpha = .71$.

Tools

The educational electronic book

The e-book used in this study was a specially constructed electronic version of *Yuval Hamebulbal* (*Confused Yuval* by Miriam Roth, 2000), adapted to capture general educational principles, especially those supporting literacy development; at the same time, the drawbacks identified in standard e-books were avoided (de Jong & Bus, 2003; Korat & Shamir, 2004; Shamir & Korat, 2006). The story's

protagonist, Yuval, was a young boy who tended to be confused and forgetful until his grandmother made him a special hat to help him remember. Each of the book's 15 pages had a large colored drawing, covering at least half the page; 3–5 written sentences per page, totaling not more than 40 words, also appeared. The written text was printed in pointed letters (*nekudot* in Hebrew, indicating vowels) so that beginning readers could relate to the printed text. The story's structure and simple narrative elements—setting, characters, goal/initiating event, problem and solution/ending (Mandler & Johnson, 1977)—were eminently suitable for the study's participants.

Main e-book functions

To establish coherence between the test groups, we scanned the printed book's pages when producing the e-book. An animated figure that explains the different activation options was added to the electronic version. The children were offered three interactive modes of operation: (1) read story only, (2) read story with dictionary, and (3) read story and play (focusing on phonological awareness activations). Each mode included an audio recording of an adult, the narrator, reading the printed text. The e-book also included automatic dynamic visuals designed to dramatize story details, fragments and scenes; extra music and film effects helped transform the e-book into a living book. To avoid distraction from the reading task, we limited the numbers of automatic dynamic visuals available to a maximum of five per page. To stimulate a pro-reading orientation, the e-book included a forward button (a colored arrow pointing to the right) and a backward button (a colored arrow pointing to the left) on each screen; these arrows allowed children to return to previous screens or to continue onto the next screen at will. Another function enabled children to repeat their reading/listening to the text. By highlighting written phrases as the text was read aloud, the program helped children focus on the relationship between the printed text and the auditory reading, an exercise believed to enhance word recognition and reading (de Jong & Bus, 2002).

Description of the main modes

The read story only mode included an auditory reading of the printed text as well as automatic dynamic visuals that dramatized the story with extra music and film effects. The read story with dictionary mode offered the same auditory reading together with explanations for 10 difficult words that appeared automatically on the screen after the entire page had been read by the narrator (children could reactivate the dictionary at will). As each difficult word appeared on the screen, it was pronounced clearly by the narrator while pictures supporting its meaning were shown. The read story and play mode was designed to promote the children's story understanding and phonological awareness. By clicking on hotspots as they appeared on (a) characters or objects and (b) words appearing in the text, children could activate the story. Activation was designed to enrich story comprehension by initiating a discourse between the main characters and the voice/sound effects. The hotspots associated with selected words were devised to promote phonological

awareness of a word's syllables and sub-syllables. For example, when the word "Yuval" (the hero's name) was shown, pressing on the hotspot revealed the word divided into its syllables and sub-syllables, simultaneously read aloud by the narrator. Hotspots were programmed to be activated only after the narrator had completed his reading of a page's text.

Children's emergent literacy level

All three groups were tested, pre and post, for the selected emergent literacy skills: vocabulary, phonological awareness, and CAP.

Vocabulary

Children were asked for the meanings of 10 words taken from the story's text; these same words also appeared in the e-book's dictionary mode. The words selected were judged to be relatively difficult for children of this age and not part of the regular kindergarten curriculum; they were also the most difficult words in the book. Taking into consideration our population (preschoolers at risk for LD), we designed a vocabulary test that asked the children to point to the one picture out of a set of four that best illustrated a word's meaning pictures; these pictures were different from those provided in the e-book's dictionary mode. Three easy words, representing a preliminary phase, were first presented to the children so as to allow them to understand the task as well as feel successful. Each of the 10 additional words was then aurally presented to the children; they were again asked to point to the picture that best illustrated the word's meaning. Each correct answer received 1 point (total score range 0–10). This measure's reliability was $\alpha = .71$ because the words belonged to various difficulty levels. For instance, the words ranged from the easy word *meihal* (a big bottle) to the very difficult word *lirtom* (to harness).

Phonological awareness

Phonological awareness was measured using 12 two-syllable words that did not appear in the e-book. The words were aurally presented, one at a time; the children were then asked to repeat them in a sub-syllabic format (segmenting them into three parts, with the last part including a sub-syllabic division: for example, in *Yu-va-l*, the word's last phoneme, the "l", separated from the others). The scores for each word in the sub-syllabic subtest ranged from 0 to 5, depending on the degree of accuracy with which the child broke the word into its three parts. Scores were assigned as follows (note: as in the test situation, the illustrated word does not appear in the e-book:

5 points: The child divided the word as instructed and as shown in the e-book: *ducan* (a stand) > du-ca-n
4 points: The child divided the word sub-syllabically but not as instructed or shown in the e-book: *ducan* > d-u-can

3 points: The child divided the word into three parts by doubling a vowel: *ducan* > du-u-can.
2 points: The child divided the word into three parts by doubling a syllable: *ducan* > du-ca-can.
1 point: The child divided the word into three parts by adding a foreign phoneme to the word: *ducan* > du-can-t.
0 point: The child divided the word into two parts or stated that she did not know how to divide the word into three parts.

There were 12 words; scores ranged between 0 and 60. The inter-rater reliability of the scoring for this part of the research was first examined on a sub-sample of children ($n = 10$) by two raters who rated each child using the scoring method described above. Only after 90% agreement was reached did one rater analyze the remainder of the participants' responses. The alpha score for this measure was .93.

Concept about print

To assess this capacity, we used the version of the CAP test specially adapted to the Hebrew language (Shatil, 2001). This test asks children to answer 16 questions about print concepts such as page, line, writing, drawing, knowledge of book and text handling as well as the direction in which reading proceeds (from right to left in Hebrew). In this version of the CAP test, each correct answer received a score of 1; incorrect answers were scored 0 (total score range = 0–16). Shatil (2001) has reported a Cronbach alpha reliability coefficient of .81 for this test.

Procedure

The pre-intervention stage

Prior to the intervention, the cognitive, word meaning and phonological awareness tests were administered. Considering the fact that the participants were at risk for LD, we conducted the tests in two sessions, no more than 5 days apart. In the first session, the children received the verbal and non verbal tests belonging to the Kaufman inventory. In the second session, the children were tested with the vocabulary, CAP, and phonological awareness measures. The order of the tests was the same for all the children. No more than 3 weeks elapsed between the assessment of the first and the last child in the sample.

E-book activity

The children worked with the e-book in a total of six structured activity sessions—two in the "read only mode", two in the "read story with dictionary mode", and two in the "read the story and play" mode, based on teachers' suggestions of how to use e-books in their classes. That is, the children were exposed to the e-book story six times, twice in each computerized mode, the same total number of times that children in the printed book group heard the story read to them. Each session lasted

20–35 min. Only six sessions were held as a result of pilot study findings indicating that motivation to work with the same e-book among children in this age group decreases significantly after the sixth experience.

After the participants were shown how the software operated, they were given the following general instructions: "We've brought you a new e-book that we would like you to work with. After you've finish working with the computer, we'll ask you some questions about the story. That's why we want you to look carefully at the pictures but also at the text".

Adult reading of the printed book

The same experimenter, an undergraduate student in special education, read the printed book to the children in each of the six activity sessions (the same number of times that the children in the other intervention group read the e-book). The class's regular teacher introduced the experimenter as a colleague and explained that she was going to read them a story. The experimenter then read the book to the children in the reading-as-usual format for the same number of sessions as in the e-book intervention. Each of these sessions lasted about 20 min. Based on 20 kindergarten teachers' responses to a questionnaire, a protocol had been formulated that described how teachers generally read books to the class (see Appendix 1 for an example). The protocol included comments and questions, targeted at transcending the plot (see de Jong & Bus, 2004, for a similar method), and explanations for the same 10 vocabulary words appearing in the e-book's dictionary.

Prior to reading the story, the experimenter presented the book to the children (the cover with the book's title, the author's name and a picture). In the first reading, the story was read straight through, without any interruptions for comments or questions. During the second to sixth readings, the experimenter asked questions, made comments and provided explanations for the selected vocabulary words at set points throughout the story. Both the experimenter and the children sat with the book facing them during the reading activity to enable their viewing the text and illustrations throughout each session, which was conducted with small groups of 3–5 children. Although all the children's questions were answered, the experimenter was told to be brief in her responses so as to ensure that all the children received similar treatment and that the reading protocol was consistently followed. Regarding the questions asked of the children during the reading activity, the experimenter provided the correct answers irrespective of how the children responded.

In designing the study, we were aware that in order to maintain the authenticity of the reading-as-usual context, we could not compare individual activity with exposure to printed books in the absence of an adult. Children at this age are incapable of reading independently; stories are read by an adult either with a printed book or narrated within the e-book program. Independent book encounters generally consist of visual activities, not "reading". By exposing the children to the same story six times in both settings, we were able to introduce a level of consistency necessary to conduct comparisons related to the unique features of each context.

Regular learning activity

It is important to note that children in the control group did not experience any structured intervention. Israeli kindergarteners are usually aged 5–7. Formal instruction in reading and writing begins upon entry into elementary school. Special education kindergarten classes follow a standard program with the addition of individualized activities designed for each child separately. In these kindergartens, children are frequently read to from storybooks and voluntarily browse through books. However, no structured program for reading is implemented although participation in games involving syllabic segmentation and rhyming, aimed at promoting phonemic awareness, does take place. Most kindergarten classes have one or two computers that allow the children to become acquainted with different types of software; the computer's files sometimes contain e-books. Some kindergarten teachers encourage spelling and grapho-phonemic awareness. Little time is devoted to the recitation of the alphabet or to letter naming although work sheets for visual discrimination training (including letter discrimination) and letter copying are available (Shatil, 2001). Children in this age group usually recognize their written names and write them on their art works.

The post-intervention stage

Within 3 weeks after the intervention, all the children were assessed once more, using the same pre-intervention emergent literacy measures, given in the same order and using the same words.

Results

A preliminary analysis was conducted in order to investigate whether the participants' non verbal performance was higher than the verbal performance, as expected among the range of populations with LD. A 3 × 2 (group × verbal ability) ANOVA was performed on the responses, with the last variable employed as a repeated-measures variable (verbal/non verbal), based on the results from the KABC subtests (see Table 1). The ANOVA results obtained were significant with respect to the differences between the verbal and non verbal measures ($F(1,104) = 109.63$, $p < .001$, $\eta_p^2 = .51$; $d = 1.176$).

As expected, the scores on the non verbal measure ($M = 6.76$, SD = 1.24) by adjusted mean age were higher than the scores on the verbal measure ($M = 5.40$, SD = .95) by adjusted mean age, as prescribed by the table in the KABC manual. No significant interaction was found for group × verbal/non verbal ability ($F(2,104) = .13$, $p > .05$). That is, no differences were found between the three groups tested regarding the gap between verbal and non verbal ability. The gap remained similar for all three research groups throughout the research. These findings indicate that all the participants did comply with the selected criterion among those defining populations at risk for learning disabilities (NJCLD, 2006), specifically, low levels of verbal ability.

In the following, the research findings are presented according to the study's goals, in the following order: the effect of e-book activity on (a) vocabulary, (b) phonological awareness, and (c) CAP.

Effect of e-book activity on vocabulary

The children's pre-intervention vocabulary scores showed no significant group differences (e-book activation/printed book/control) ($F(2, 107) = .93$, $p > .05$) .

To test for the effects of the e-book activity on vocabulary, we used a 3 × 2 repeated measures ANOVA of *group* (e-book activation/printed book/control) × *time* (pre- and post-intervention), with time serving as the repeated-measures variable. There was a significant main effect for time ($F(1,107) = 300$, 34, $p < .001$, $\eta_p^2 = .74$), indicating that children's post-intervention vocabulary scores were higher than their pre-intervention scores. There was also significant interaction between *group* and *time* ($F(2,107) = 42.08$, $p < .001$, $\eta_p^2 = .44$), indicating that the pre- to post-intervention differences in vocabulary improvement varied among the three groups compared. The means and standard deviations of these scores for all groups appear in Table 2.

Simple effects analyses for dependent samples, carried out for each group separately, indicated that the post-test vocabulary score of the e-book group ($F(1,41) = 262.99$, $p < .001$, $\eta_p^2 = .87$) was higher than for the printed book group ($F(1,33) = 89.23$, $p < .001$, $\eta_p^2 = .30$), with both higher than the score for the control group ($F(1,33) = 15.35$, $p < .001$, $\eta_p^2 = .32$). Further analyses showed significant differences between the e-book and the control group ($F(1,74) = 98.94$, $p < .001$, $\eta_p^2 = .57$) and between the printed book and the control group ($F(1,66) = 34.85$, $p < .001$, $\eta_p^2 = .35$). In addition, significant differences were found between the e-book and the printed book group ($F(1,74) = 7.68$, $p < .01$, $\eta_p^2 = .09$), with the e-book group showing the highest improvement in vocabulary between the pre- and post-intervention phases.

As can be seen from Table 1, the effect size of the e-book group ($d = 2.23$) and that of the printed book group ($d = 2.07$) were both high whereas the effect size of the control group was low ($d = .51$). These findings imply that improvement in vocabulary was high in the e-book as well as the printed book group, and that both exceeded that of the control group.

Table 2 Vocabulary acquisition: pre and post means and standard deviation

Vocabulary (score range 0–10)					
Condition	Pre		Post		d[a]
	M	SD	*M*	SD	
E-book	4.71	1.59	8.26	1.27	2.23
Printed book	5.06	1.25	7.65	1.45	2.07
Control	4.62	1.32	5.29	1.40	.51

[a] According to the Cohen *d* test, a value of .75 or higher indicates a powerful difference whereas a value of .25 indicates a weak difference; in-between values indicate moderate differences

Table 3 Phonological awareness: pre and post means and standard deviations

Sub-syllabic segmentation (score range 0–60)					
Condition	Pre		Post		d[a]
	M	SD	*M*	SD	
E-book	40.51	13.43	49.71	9.95	.69
Printed book	39.81	16.6	41.67	15.55	.11
Control	40.97	16.75	41.97	17.56	.06

[a] According to the Cohen *d* test, a value of .75 or higher indicates a powerful difference whereas a value of .25 indicates a weak difference; in-between values indicate moderate differences

Effect of e-book activity on phonological awareness

The subjects' pre-intervention *phonological awareness* scores showed no significant group differences (e-book activation/printed book/control) ($F(4, 212) = .18$, $p > .05$).

To test for the effect of e-book activity on this variable, we used a 3 × 2 repeated-measures ANOVA of *group* (e-book activation/printed book/control) × *time* (pre and post intervention), with time employed as a repeated-measures variable. There was a significant main effect for time ($F(2,105) = 22.75$, $p < .001$, $\eta_p^2 = .30$), indicating that children's post-intervention phonological awareness scores were higher than their pre-intervention scores. There was also a significant interaction between *group* × *time* ($F(4,212) = 4.38$, $p < .01$, $\eta_p^2 = .08$), indicating that the pre- to post-intervention differences in phonological awareness improvement varied among the three groups. The means and standard deviations of the pre- and post-intervention sub-syllabic segmentation scores for the three groups are shown in Table 3.

As can be seen from Table 3, significant differences were found in sub-syllabic segmentation ($F(2,106) = 7.27$, $p < .01$, $\eta_p^2 = .12$) between the groups. Simple effects analyses for the dependent samples, carried out for each group separately, indicated that only the e-book group showed significant improvement between the pre- and post-intervention phases with respect to sub-syllabic awareness ($F(1,41) = 22.80$, $p < .001$, $\eta_p^2 = .36$). No such improvement was found in either the printed book group ($F(1,32) = .1.02$, $p > .05$) or the control group ($F(1,33) = .75$, $p > .05$). Looking at Table 3, we see that effect size of the e-book group ($d = .69$) was high whereas effect size of the printed book group ($d = .11$) and that of the control group were low ($d = .06$), indicating that improvement in sub-syllabic segmentation was highest in the e-book group.

Effects of e-book activity on concept about print (CAP)

The kindergarteners' pre-intervention CAP scores showed no significant group differences (e-book activation/printed book/control) ($F(2,107) = .69$, $p < .05$).

To test for the effect of the e-book activity on CAP, we used a 3 × 2 repeated-measures ANOVA of *group* (e-book activation/printed book/control) × *time* (pre

Table 4 Concept about print (CAP): pre and post means and standard deviations (score range 0–16)

Concept about print (CAP)					
Condition	Pre		Post		d^a
	M	SD	*M*	SD	
E-book	8.83	2.81	49.71	10.79	.70
Printed book	9.55	2.25	41.67	11.18	.72
Control	9.32	2.32	41.97	9.97	.28

[a] According to the Cohen *d* test, a value of .75 or higher indicates a powerful difference whereas a value of .25 indicates a weak difference; in-between values indicate moderate differences

and post intervention), with time serving as a repeated-measures variable. There was a significant main effect for time ($F(1,106) = 77.11, p < .001, \eta_p^2 = .42$), indicating that the children's post-intervention CAP scores were higher than their pre-intervention scores. There was also a significant interaction between *group* × *time* ($F(2,106) = 6.04, p < .01, \eta_p^2 = .11$), indicating that the pre- to post-intervention differences in CAP improvement varied among the three groups. The means and standard deviations of the pre- and post-intervention CAP scores are shown in Table 4.

Simple effects analyses for dependent samples, carried out post intervention for each group separately, indicated that improvement in the e-book group ($F(1,41) = 56.63, p < .001, \eta_p^2 = .58$) and the printed book group ($F(1,32) = 37.39, p < .001, \eta_p^2 = .54$) was much higher than in the control group ($F(1,53) = 4.53, p < .05, \eta_p^2 = .12$). Further analyses showed significant differences between the e-book and the control group ($F(1,74) = 10.79, p < .01, \eta_p^2 = .93$) and between the printed book and the control group ($F(1,65) = 5.94, p < .01, \eta_p^2 = .08$). No significant differences were found between the e-book and the printed book group ($F(1,73) = .70, p < .05$).

As can be seen in Table 4, the effect size of the e-book group ($d = .70$) and that of the printed book group ($d = .72$) were both high, implying that improvement in CAP was high with both tools.

Discussion

In the study reported here we investigated the extent to which the reading/listening and activation of an educational e-book can promote vocabulary, phonological awareness and CAP, three fundamental emergent literacy skills, among children at risk for LD. Activity with the e-book was compared to reading the printed version of the same book, with both contexts compared to the control situation, where children at risk for LD were exposed to the regular kindergarten curriculum. The findings showed that the group experiencing the e-book intervention exhibited greater progress in vocabulary and phonological awareness (sub-syllabic segmentation) than did the other groups. However, although the two intervention groups showed greater improvement than did the control group in their CAP scores, no significant

differences on this dimension were found between the e-book and the printed book group.

A number of studies have been carried out to ascertain whether children at risk (Littleton et al., 2006; McKenna & Reinking, 1997; Verhallen et al., 2006) and those with special needs (Segers et al., 2006; Segers & Verhoeven, 2008) can benefit from an e-book with respect to growth in vocabulary. Regarding kindergarten children with special needs resulting from physical disabilities, Segers et al. (2006) have reported findings from small-scale research indicating greater improvements in vocabulary retention among children exposed to a computer-read story than among their control peers, who were exposed to a printed book read by a teacher as part of the regular program. To the best of our knowledge, no other comparable research has been conducted to evaluate the e-book's contribution to emergent literacy specifically among kindergarten children at risk for LD.

The literature also shows that children with LD do have problems developing the emergent literacy skills tested in our research (Bryant, 2003; Hutinger et al., 2005; Jenkins, Matlock, & Slocum, 1989; Most et al., 2000). These difficulties are assumed to affect later acquisition of reading and writing in school (Lange & Thompson, 2006; Lyon, 1995; Stanovich, 1991) and may undermine the motivation to engage in reading-related activities.

When comparing our results in the area of vocabulary acquisition between the educational e-book and the printed book versions of the same story, it should be remembered that the children in both groups were exposed to explanations of the same words. The greater improvement in vocabulary shown by the e-book group may be explained by at least three factors, all of which relate to the type and, perhaps more importantly, the unique structure of the interactivity offered by the e-book. Computers allow children to be exposed to explanations presented contiguously in qualitatively different forms (Mayer, 2003; Neuman, 2009); computers therefore provide mutually referring sources of information (Moreno & Duran, 2004). Children can consequently interact with texts in ways not permitted by printed books (Shepperd, Grace, & Koch, 2008). Put simply, computers can present vocabulary in combination with various opportunities for enhancing different cognitive faculties. Moreover, as noted by Verhallen et al. (2006), the richness of the multimedia features available in e-books may, in and of themselves, imbue messages with new content and thus promote more-effective learning than static book reading does. As Verhallen et al. (2006) conclude, "young children best recall salient actions that are clearly visualized by pictures or an action movie … and that they do less well on implied story elements" (p. 417). Provision of mutually referring sources of information through multimedia platforms supports such learning (Moreno & Duran, 2004).

When explaining our findings, it is possible to argue that the unique design of the read story with dictionary mode had a stronger effect on learning than did the exclusively verbal explanations commonly given by teachers when reading the story's printed book version. We again wish to stress that the dictionary mode provides auditory explanations in combination with meaning-supporting pictures, presented in a lively format (including music and sound effects) that appear as part of the computerized learning activity. Although the pictures are static, they require

activation of the relevant hotspot by the child. These pictures can thus be considered a multimedia feature, part of the multi-sensory active learning that has been shown to be crucial for compensating deficiencies in the perception and memory of children at risk for LD (Bulgren & Carta, 1993) given their limited short-term memory (Adams & Gathercole, 2000; Lipka et al., 2006). In light of the children's assumed perceptual and memory disorders, further research is needed to investigate the effect of static versus animated illustrations for learning.

Furthermore, although the same words were explained to both groups, the children in the e-book group were able to activate the dictionary mode as often and as long as they chose after being exposed to these difficult words during the initial reading. It is possible that the combined effect of vocabulary first read and highlighted in the e-book, followed by self-initiated activation of the interactive dictionary was more supportive of meaning-retention than is vocabulary explained exclusively by a teacher when reading-as-usual.

Another possible explanation for these findings is that the interactivity of the dictionary mode increased the amount of attention paid to vocabulary. Because interactivity may be more engaging than straightforward explanation of words—the usual method adopted in kindergarten learning situations—such software may have prevented attention lapses (or "zoning out"; see Schooler, Reichle, & Halpern, 2005).

In line with previous findings obtained from research on educational e-books conducted with typically developing preschoolers (Shamir, 2009; Shamir et al., 2008), the results of the current study show that preschoolers at risk for LD—that is, young children exhibiting low levels of verbal ability rooted in neurological issues—can learn the meaning of infrequently used as well as new words if provided with an appropriate dictionary option. Yet, irrespective of the significant positive results obtained with e-book use, these results should be considered with caution. The fact that the effect sizes (Cohen's *d*) for the e-book group and the printed book group were both high implies that the two learning contexts are of great value for acquiring vocabulary, each in its own way. There is little doubt that adult reading is of primary importance for children's development. We wish to stress that because e-books provide computerized versions of the books read by teachers and parents, they are in effect variations on this basic learning experience. The significant and positive results obtained for the e-book in our experiment therefore confirm its potential utility as a supplementary tool for classroom instruction. This may be especially true for children at risk for LD who, as stated, need more multi-sensory active learning experiences (Bulgren & Carta, 1993; Swanson et al., 2003). From a practical perspective, the possibility of independently "reading" e-books can potentially ease the teacher's burden under contemporary classroom time constraints.

Another striking finding of the current research relates to the fact that greater improvement in sub-syllabic phonological awareness was observed among the children who activated the educational e-book as opposed to the other two groups. We suggest that this improvement was due to the children's activity in the read story and play mode. It is possible that when children activate hotspots programmed to promote phonological awareness, they more easily internalize the phonological structure of the words because they simultaneously listen to and view words in a multimedia, syllabicated format (Mayer, 2003). These findings are important

because they indicate that when exposed to the authentic experience of e-book reading, children at risk for LD who do exhibit difficulties with phonological awareness (Fletcher, Reid, Fuchs, & Barnes, 2006; Swanson et al., 2003) may benefit from e-book interventions. The greater improvement in phonological awareness among the children in the e-book group when compared to the control group provides evidence for the e-book's effectiveness regarding this skill. Yet, because children in the printed book group did not receive any intervention regarding phonological awareness, we cannot reach the same level of conclusiveness for groups other than those tested in the research. In order to achieve results with greater generalizability, we suggest that research comparing phonological awareness among children at risk for LD with that among typically developing children be conducted using standardized tools when assessing these skills. Such data are currently unavailable.

We should recall, however, that previous studies with typically developing children have already shown that e-book activity can promote phonological awareness (Chera & Wood, 2003; Littleton et al., 2006; Olson & Wise, 1992; Shamir, 2009; Shamir et al., 2008). For example, Olson and Wise (1992), who compared software based on phonological awareness as opposed to whole-word reading, found that while all children benefited from computer-assisted learning, those using phonologically targeted software benefited most. Others have reported that exposing beginner readers (that is, those already in a formal reading program) to e-books including phonological awareness features at the level of onset and rime can promote reading strategies (Littleton et al., 2006) as well as phonological awareness (Chera & Wood, 2003). It should be remembered, however, that the current research focused on kindergarteners at risk for LD. Any tool that can help these children overcome such issues deserves further investigation (NJCLD, 2006).

Turning to concept about print, the fact that improvements in CAP were similar in the e-book and the printed book group may indicate that educational e-books, like printed books, can support this skill. We suggest that even though not all features available in the e-book were also available in the printed book, our findings resulted from some parallels in presentation. For instance, the appearance of page numbers on the screen and the highlighting of text (whole sentences as well as separate words) while listening to the story's narration may help children follow the e-book's written text in a manner similar to being shown words on a page while listening to a printed book read aloud. The e-book's forward and backward buttons may also simulate page-turning. Although the literature includes no research on this subject among children at risk for LD, Shamir et al. (2008) did obtain findings in this direction among typically developing children Further research is clearly needed to clarify this issue.

Conclusion

The effectiveness of multimedia additions for enhancing emergent literacy among children at risk has already been reported in the literature. We therefore wish to stress that the contribution of the current research lies in the fact that we have

provided, for the first time, similar evidence pertaining to a particular segment of the special needs population, specifically, young children at risk for LD. The comparisons conducted between the edutainment format and the adult reading context (reading-as-usual) enabled measurement of the hypothesized variations in the acquisition of three emergent literacy skills (vocabulary, phonological awareness and CAP).

The outcomes of the present research imply that work with specially designed educational e-books may be a good avenue for promoting vocabulary and phonological awareness for this at risk population. As noted, not all children at risk for LD necessarily confront the same difficulties. Because confidentiality prevented a more precise categorization of the participants, we applied four selection criteria to compensate for this constraint. Given that, the selected group of children did benefit from the intervention; we can therefore conclude that e-book activities targeted at promoting phonological awareness and vocabulary may be beneficial for other at-risk children as well. Further study is needed to confirm this conclusion.

Our discussion cannot close without mentioning some limitations of the current research. To put these limitations in perspective, we should recall that the purpose of the current research was to investigate two separate but ecologically valid and authentic contexts characterizing the kindergarten classroom; hence, not all the variables could be controlled within each context. In addition, no data were collected pertaining to the in-depth mapping of the mechanisms underlying processual aspects of learning with e-books. Future research should be designed to illuminate how often children activate hotspots and other effects and whether frequency, order and additional aspects of activation impact on an e-book's educational effectiveness. Such research could be quite meaningful with respect to phonological awareness hotspots and the dictionary mode in particular because the possibility of self-initiated activation of hotspots implies that the children probably spent more time working with the e-book than they did listening to the printed book version read by an adult.

The desire to replicate a reading-as-usual context in the control situation prevented direct comparisons of all emergent literacy skills. The current findings did, however, indicate greater improvement in phonological awareness in the e-book versus the control group. This finding is promising because it confirms previous results obtained with typically developing children (Shamir et al., 2008). Future research should investigate how tools to improve phonological awareness can be introduced into adult reading sessions prior to conducting comparisons between contexts.

Finally, we should consider the possibility that something of the flavor of the reading-as-usual approach may have been lost in our attempt to standardize this type of reading for experimental purposes. For instance, the teacher's sudden replacement by the experimenter might not have been automatically accepted. We believe this to be a sensitive issue with respect to all experimental contexts, especially among very young children.

We treat the research findings indicating, for the first time, that e-books are effective for improving the selected skills among young children at risk for LD as signs calling for in-depth mapping of processual aspects of learning with e-books.

Such an investigation should be conducted among all types of children and for the full range of learning skills.

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Appendix 1: Adult reading to children

Children were read the printed book by the same experimenter six times (the same number of times that the children read the e-book). The experimenter's reading was structured according to a protocol based on responses to a questionnaire administered to 20 kindergarten teachers. Prior to the reading, the experimenter presented the book to the children (the book's name and author, in a way similar to the e-book presentation).

In the first reading, the story was read straight through, without any interruptions for comments and questions. During the second to sixth readings, the experimenter made comments and provided explanations about the plot and selected vocabulary (the identical 10 words explained in the e-book's dictionary), a format resembling reading-as-usual by teachers to kindergarteners. Brief answers were also given to questions that children posed regarding the plot or vocabulary. Following are some examples.

Page no	Objective	Print version (teacher reading-as-usual)
Cover	Presentation of the cover's elements	The name of this book is *Yuval Hamebulbal* (*Confused Yuval*); it was written by Miriam Roth. Here is Yuval. Let's see what happened to him
1	Presentation of the main characters	Look; here is Yuval and here is his rabbit
2	Word definitions	Defining the word "stretching": Who knows what it is to stretch? Let's stretch together
	Comment	Here is Yuval waking up, why do you think he is in a hurry?
8	Word definition	Defining the word "hidden" with a more common synonym
	Comment aimed at connecting the situation to the child's world	What happened to Yuval's shirt? Have you ever gotten confused when getting dressed? Who helped you?
	Word definition	Defining the word "twice": two times. The experimenter provides additional examples using a more common synonym
	Comment aimed at connecting the situation to the child's world	Do you sometimes get confused when putting on your shoes? Is it easier to put on your shoes when you're standing up?
22	Comprehension question	Why doesn't his daddy's hat fit Yuval? (Expected answer: Because it's too big and covers his eyes)
30	Comment transcending the plot	See how happy Yuval is now when waking up. The first thing he does is to put on the hat that Grandma made for him

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