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On-screen children's stories: The good, the bad and the ugly

Takacs, Z.K.

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Author: Takacs, Zsofia Katalin

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CHAPTER 5

THE BENEFITS OF MOTION IN ANIMATED STORYBOOKS FOR CHILDREN'S COMPREHENSION: AN EYE-TRACKING STUDY

Based on:

Takacs, Z. K. & Bus, A. G. (under review). *The benefits of motion in animated storybooks for children's comprehension. An eye-tracking study.*

ABSTRACT

The present study provides experimental evidence regarding 4-6-year-old children's visual processing of animated versus static illustrations in storybooks. 39 participants listened to an animated and a static book, both three times, while eye movements were registered with an eye-tracker. Outcomes corroborate the hypothesis that specifically motion is what attracts children's attention while looking at illustrations. It is proposed that animated illustrations that are well matched to the text of the story guide children to those parts of the illustration that are important for understanding the story. This could explain why animated books resulted in better comprehension than static books.

Young children are attracted to screen media like cartoons and television programs that include motion, music and sound. In fact, children seem to prefer a multimedia presentation of stories over a static presentation as in more traditional print books and are more engaged with multimedia materials. Verhallen and Bus (2009) found that skin conductance – an indicator of children's mental effort during listening to storybooks - remained at the same level over four repeated readings of a story when the book included multimedia features like motion pictures, music and sound effects. However, mental effort decreased in the third and fourth repetition when the same story included only static illustrations. Moody, Justice, and Cabell (2010) revealed that children were more persistent when sharing an e-storybook as compared to sharing a traditional print storybook with an adult. On the other hand, when watching multimedia content children are especially attentive to salient formal features like rapid action (Potts, Huston, & Wright, 1986), animation, motion, lively music and auditory change (Alwitt, Anderson, & Lorch, 1980; Levin & Anderson, 1976). Such elevated attention to salient features like motion might guide children's attention when watching an illustration, which may explain the overall greater engagement with multimedia than with static stories (Verhallen & Bus, 2010). The present study investigated whether motion in animated illustrations in electronic storybooks attracts more attention and whether there is, probably as a result of looking longer at details in motion, an overall elevated visual attentiveness when listening to animated versus static books.

In contrast to concerns expressed in older literature for a “mesmerizing” effect of multimedia on children's cognitive development (e.g., Hayes & Birnbaum, 1980), there is evidence for the potential of multimedia for fostering learning. It is apparent from the literature on electronic storybooks that multimedia features, as long as the verbal text of the story on the one hand and the pictures and sounds on the other are well matched, boost the effects of storybook reading on young children's story comprehension and word learning (for meta-analytic evidence see Takacs, Swart, & Bus, 2014, 2015; for a review see Bus, Takacs, & Kegel, 2014). In explanation, we hypothesized that by processing details of pictures in books at exactly the same time as the oral text – children's eyes focus on those parts of the illustration that are highlighted by the text – children may integrate verbal and visual information which improves understanding of the text (Bus & Verhallen, 2011; Evans & Saint-Aubin, 2005; Verhallen & Bus, 2011). The human brain is able to process both sources of information - verbal and nonverbal stimuli - simultaneously without causing cognitive overload. The two kinds of stimuli are processed in separate but interconnected channels (Paivio, 2007). So far there is not much empirical evidence

for an alternative account - the visual superiority hypothesis (Hayes & Birnbaum, 1980) - proposing that looking at motion pictures is more appealing to young children than listening to the oral language (Bus et al., 2014; Rolandelli, 1989). According to this view, one could argue that motion pictures may distract children's attention from the verbal narration and impose a cognitive overload on children's working memory and thus interfere with story comprehension and learning new vocabulary.

The current study zoomed in on the effect that motion in illustrations has on children's eye movements and on subsequent story comprehension and word learning. This study is, to our best knowledge, the first to test the hypothesis that multimedia features like motion direct children's visual attention to details in the picture that are highlighted by the text resulting in more attention to those details than during reading a book with still pictures. Motion in the illustration might thus help to concretize story language more than a static illustration. For example, in Figure 1 the angry director is actually jumping up and down in the animated condition and thus attracting the most attention despite many other visualized story details. Additionally, motion, better than static illustrations, guides children's attention to depictions that match the oral text that children simultaneously hear. For example, the director - the only motion in the picture - is angrily jumping while the text says: "*These are not monkeys!*" he shouted jumping "*These are people!*". We may thus enhance story comprehension and learning words because the closer together the verbal and nonverbal information are presented the more the integration of the two is facilitated (Mayer, 2003). As a result, children's overall attentiveness and engagement when listening to stories may be higher with animated as compared to static illustrations (Moody et al., 2010; Verhallen & Bus, 2009).

In the present study children repeatedly listened to two stories: one with static pictures and another with animated illustrations. Both books were presented three times on an eye-tracker. We utilized eye-tracker data two ways: First, to register children's overall visual attention to the illustrations when listening to animated or static stories as an indicator of engagement. Secondly, in order to test whether motion in illustrations indeed attracted children's attention more than the same details in static illustrations, we selected three pages per book with a detail in motion and compared visual attention for this detail with attention for the same detail in the static version of the book. Total fixation time and average fixation duration were assessed. To the best of our knowledge, this was the first study comparing children's visual attention to animated and static details in pictures.

Third, we examined, apart from children's recall of the story language, their learning of new words as a function of animated versus static pictures. Previous studies have shown that it makes a difference for word learning whether children have some receptive knowledge of words or not (Smeets & Bus, 2012; Verhallen & Bus, 2010). Differences in experiences with words strongly vary across children and make it hard to determine how much learning resulted from repeated readings of a particular book. To maximally control for differences in word knowledge prior to exposure to the word in the target books we preferred adding non-words to the books for three well-visualized words from the story text. This way we were sure that children did not have any previous knowledge of the target words.

HYPOTHESES

1. Based on the previous literature showing an advantage of multimedia-enhanced stories over print-like static stories (Bus et al., 2014; Takacs et al., 2015), we expected that children would recall more from the language of the story when encountering stories with animated as compared to static illustrations.
2. Animated illustrations representing the meaning of non-words may, more than static illustrations, facilitate the learning of the non-words (Smeets & Bus, 2014). Since the non-words were completely unknown we expected effects on receptive knowledge rather than on expressive word knowledge (Smeets & Bus, 2012; Verhallen & Bus, 2010).
3. We expected that children would be more visually attentive to illustrations that include motion than to static illustrations (Moody et al., 2010; Verhallen & Bus, 2009). As a result, children were expected to fixate the illustrations in an animated book longer than those in a static book.
4. Details in motion were expected to attract more attention than static details (Alwitt, Anderson, & Lorch, 1980; Levin & Anderson, 1976). Accordingly, longer fixations were predicted on the detail that is in motion compared to the same detail in a static illustration.

METHOD

PARTICIPANTS

Children were recruited in 3 public schools from 5 kindergarten classrooms with 4-, 5- and 6-years-old children who had not yet received formal reading instruction. In the Netherlands formal reading instruction including intensive daily practice starts in grade 1. Parents of 43 children gave informed consent for participation of

their child in the study. Among the 43 children were 3 children who were excluded from the study because they were siblings of other participants. Also, one boy's eye-tracking data collected at the second session was lost and he was excluded from all further analyses. The final sample consisted of 39 children (22 boys and 17 girls) with a mean age of 61.26 months ($SD = 7.69$, range: 48-77 months). From the three participating schools we recruited 9, 6, and 24 children, respectively. To control for any effects of school, it was entered as a factor in the analyses.

DESIGN

The study was a within-subject design in which every child participated in three conditions: a storybook with animated illustrations, a storybook with static illustrations and a control condition, including only post-testing and no book reading. The illustrations in both the animated and static conditions were presented for the same amount of time and with the same oral narration, the only difference being the presence of motion and zooming in on the illustrations. Three storybooks can be assigned to three conditions in six different ways. 40 participants were about equally assigned to these six possibilities. However, not completely. Four groups included 7 children, one group 5 children and one 6. As a result, the books were not completely evenly distributed over the three conditions. For instance, in the animated condition 14 children read *Bear is in Love with Butterfly* [*Beer is op Vlinder*] (van Haeringen, 2004), 12 *Imitators* [*Na-apers!*] (Veldkamp, 2006), and 13 *The Little Kangaroo* [*Kleine Kangoeroe*] (van Genechten, 2009).

PROCEDURE

Children were taken from the classroom to a quiet location in the school on two days. As shown in Table 1, on the first day children listened twice to both stories, one in the animated format and the other in the static format. To register visual attention the books were presented on the screen of an eye-tracker. The animated version of a book was presented for the same amount of time as the static version of the same book. The order of the animated and static book was alternated and half of the children started with the animated and half with the static book.

On a second day, on average two days later ($M = 2.00$, $SD = 1.12$), a third session took place in which children listened again to the two books right before post-testing. Post-tests included a retelling of the two stories that they had heard three times and the control story. The order of the books retold was random. We also tested knowledge of 9 non-words, three from each story. We used four vocabulary tests assessing different levels of word knowledge. The order of the four vocabulary

tests was fixed and the same for all children. The order of the retellings and the vocabulary tests was counterbalanced: 19 children started with the story retelling, while 20 children completed the vocabulary tests first. See Table 1 for an example schedule.

Table 1
An Example of the Schedule of the Experiment

Day 1	Day 2
<i>Session 1</i>	<i>Session 3</i>
Reading of animated version of <i>Imitators</i>	Reading of static version of <i>The Little Kangaroo</i>
Reading of static version of <i>The Little Kangaroo</i>	Reading of animated version of <i>Imitators</i>
<i>Session 2</i>	<i>Post-testing</i>
Reading of animated version of <i>Imitators</i>	Retellings of the three stories
Reading of static version of <i>The Little Kangaroo</i>	1. <i>The Bear is in Love with Butterfly</i>
	2. <i>Imitators</i>
	3. <i>The Little Kangaroo</i>
	Vocabulary tests:
	Expressive vocabulary test
	Context integration test
	Receptive vocabulary test
	Meaning recognition test

Note. There was 1-5 days between the two days. We tried to use the three books in the three conditions as much as possible. In the case of the above example *Imitators* was used in the animated, *The Little Kangaroo* in the static and *The Bear is in Love with Butterfly* in the control condition. The order of the animated and static condition was the opposite for half of the participants who started with the static book. The order of the story retelling and vocabulary post-tests was different for half of the children who started with the vocabulary tests. The order of the books retold was random. The order of the four vocabulary tests was fixed and the same for all children.

MATERIALS

Three animated storybooks (*The Little Kangaroo*, *Imitators*, *Bear is in Love with Butterfly*) were chosen for the 3 conditions. The text of the storybooks was slightly different from the original. In each book 3 verbs were substituted by non-words, i.e., words that do not exist in the Dutch language but sound like Dutch (see Appendix E for the list of target words). As shown in the example in Figure 1, the word 'jumping' ['springen'], for instance, was replaced by the non-word 'trinnen'. Each of the three books included 3 non-words which resulted in 9 non-existing target words. In each story two of 3 non-words were mentioned twice in the oral text and one once.

All three stories were animated by the same company (Het Woeste Woud). Background music and sound effects were present in the the animated versions of all three books but eliminated for the present study because our goal was to test the effect of motion in illustrations. To make the static illustrations similar to the animated illustrations, we selected the most representative still frame of the fragment and presented this for exactly the same amount of time as the animated illustration of the scene. There was some slight variation between the three books: *Bear is in Love with Butterfly* included 397 words, *The Little Kangaroo* 516 words, and *Imitators* 509 words. Accordingly, the duration of the readings were somewhat different too: to read *Bear is in Love with Butterfly* took 194 s, *The Little Kangaroo* 232 s, and *Imitators* 252 s. We corrected for differences in length of presentation by dividing fixation durations for the whole book by the duration of the stories.

Per book three illustrations were chosen for detailed eye-tracking analyses. We chose pictures with illustrations that clearly depicted the non-words. This detail of the illustration was in motion in the animated condition and clearly visualized in the static condition. The details were the same size in the animated and static condition. However, illustrations differed across books, not only in artistic style but also in the number of details. For example, on one of the target illustrations in *Bear is in Love with Butterfly* we see Bear playing the accordion; the only other visual element on the illustration is Butterfly with a handkerchief. In contrast, in *Imitators* shown in Figure 1 there are many smaller and larger elements beyond the angry director. The different

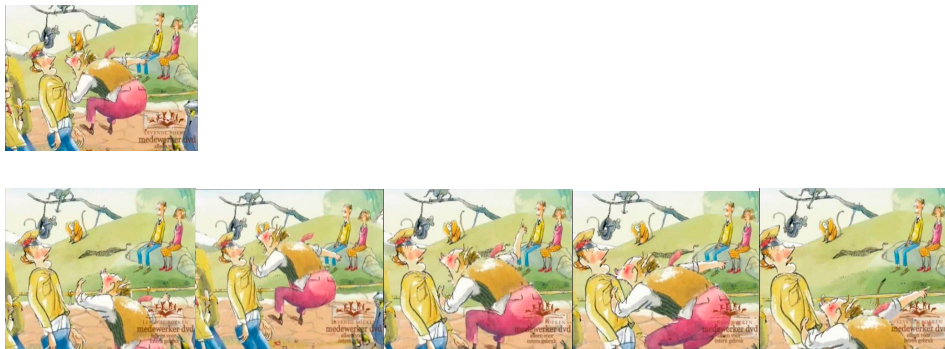


Figure 1. One of the target illustrations chosen for fine-grained analysis of the eye-tracking data. The same illustration in the static condition in the first row and still frames from the animated version¹ are shown in the second row. The director of the zoo is jumping up and down while the accompanying oral text says: "These are not monkeys!" he shouted *jumping* "These are people!". [*Dit zijn geen apen!* riep hij "trinnend", *Dit zijn mensen!*]

¹ Copyright 2014 by Het Woeste Woud.

pages were presented for slightly different amounts of time according to the length of the corresponding oral narration ranging between 3.6 and 7.1 seconds.

MEASURES

Visual attention at the illustrations. While the books were read to the children their eye movements within the illustrations were recorded. The total fixation time on the illustrations in a storybook was calculated and divided by the duration of the presentation of the book. Additionally, children's average fixation duration while looking at the storybooks was calculated. This was done for all three sessions. We defined details that visualized the non-words as Areas of Interest (AOIs). We divided the time that children fixated the AOI by the time that they looked at the whole illustration. This was done for the three AOIs per book. The average percentage was calculated as an indicator for each condition and each session. Additionally, we divided children's fixation duration at an AOI by the number of fixations as indicator of average fixation duration. The average fixation duration was also calculated for each condition and session.

For 4 children data quality was low, i.e., eye movements were registered for less than 50% of the time during at least one session in one of the conditions. Due to low data quality, these children's fixation times were extremely low. For the eye-tracking analyses these 4 children were excluded and, accordingly, data of 35 children were used. Additionally, on the 24 fixation variables outlying scores were winsorized in order to normalize the distribution of the scores. In all, 20 scores.

Story retelling. Children were asked to retell the three stories while they looked at the static illustrations of the stories. The experimenter asked general questions when children stopped talking like 'What is happening here?' or 'Who is this?'. Children's retellings were transcribed and we calculated how many content words from the original story appeared in the retellings of the stories and whether or not the non-words were used. One child refused to retell the stories so analyses regarding story comprehension were conducted on the data of 38 children.

Vocabulary tests. Familiarity with the 9 target non-words was assessed with four tests measuring receptive and expressive knowledge of the words. We started with the two expressive vocabulary tests in order to avoid learning from the receptive tests in which children heard the target words.

Expressive vocabulary test. With the corresponding illustration on the screen children were asked to complete a sentence with the non-word missing. Sentences were phrased differently than in the stories. Only answers including the target word scored 1, any other answers 0. See Figure 2 for an example. Item-level inter-rater


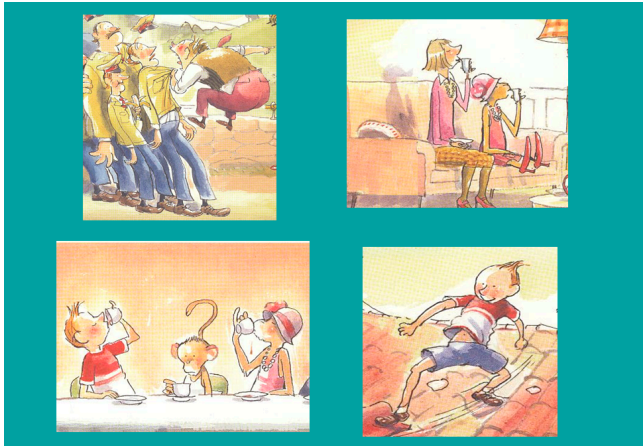
Tests	Item	Correct answer
Expressive vocabulary test	The director is so angry that he cannot stand still. He is... What is he doing here? [De directeur is zo boos, dat hij niet kan blijven staan. Hij is aan het ... Wat doet hij hier?]	'trinnen' (non-word for 'jumping')
		
Context integration test	Which way do you move when you are *jumping*? [Welke kant beweeg je op als je trint?]	E.g., up and down
Receptive vocabulary test	Where can you see... *jumping*? [Waar zie je ... trinnen?]	Picture 1
		
Meaning recognition test	1. *Jumping* is when a car is driving through a tunnel. [Trinnen is wanneer een auto door een tunnel rijdt.] 2. When you *jump* you can pick an apple from the tree. [Als je trint, kan je bij een appel die in de boom hangt.]	False True

Figure 2. Examples of the four vocabulary tests assessing knowledge of the non-word 'trinnen' which stands for the word 'jumping' including still frames from the animated version¹.

¹ Copyright 2014 by Het Woeste Woud.

reliability was excellent (average $\kappa = 1.00$). Only one child used any of the target words so no further statistical analyses were conducted on this measure.

Context integration test. The context integration test uses open-ended questions prompting an expressive explanation of the target word like (e.g., "Which way do you move when you are *jumping*?"). Only answers with information reflecting the meaning of the target word were awarded 1 (e.g., "You go up and down"), any other answers (e.g., 'to the right') were scored 0. Item-level inter-rater reliability was good (average $\kappa = .89$). Children rarely gave good answers resulting in a very skewed outcome. Thus, statistical analyses were not conducted on the this measure.

Receptive vocabulary test. This test was a multiple-choice test where children had to choose the corresponding picture from 4 options. Target pictures and distractors were chosen from the same storybooks. See Figure 2 for an example. Item-level inter-rater reliability was good (average $\kappa = .78$). More than half of the children performed above chance level (25%) in both the animated ($p < .001$) and the static condition ($p < .001$). This was not the case in the control condition ($p = .34$).

Meaning recognition test. The meaning recognition test assessed word knowledge independent from the context of the storybooks. Using two yes/no questions per word regarding the meaning of the word presented in a quasi-random order, children's receptive transfer knowledge of the non-words were tested. See Figure 2 for an example. Item-level inter-rater reliability was good (average $\kappa = .72$). Children did not perform above chance level in any of the conditions (animated: $p = .75$, static: $p = .52$, control: $p = .20$) so scores on this test was not further analyzed.

RESULTS

STORY COMPREHENSION

An ANOVA with repeated measures for recall of the story language per condition and school (school 1, 2 and 3) as a between-subject factor was carried out. Two planned contrasts were conducted regarding the effects of condition: 1. between the animated and the static conditions, and 2. between the intervention and the control conditions to test the effect of book reading. Children recalled significantly more content words from the animated as compared to the static condition ($F(1, 35) = 5.87, p = .02, \eta_p^2 = .14$) showing an advantage of animations. Also, children recalled more from the language of the animated and the static stories as compared to the control condition ($F(1, 35) = 60.45, p < .001, \eta_p^2 = .63$) suggesting an effect of book reading. See Table 2 for descriptive statistics.

WORD LEARNING

Only three out of 38 children used non-words from the story in the retelling, one in the animated and two in the static condition. Thus, the effect of condition could not be tested on these variables.

Of the four word learning tests children only showed learning in the receptive vocabulary test. On the other three tests children did not show any learning. We carried out an ANOVA with repeated measures for the receptive vocabulary test in the three conditions (animated, static, control) and school (school 1, 2 and 3) as a between-subject factor. Two planned contrasts were conducted regarding the effects of condition: 1. between the animated and the static conditions, and 2. between the intervention and the control conditions. There was no significant difference between the animated and static conditions ($F(1, 36) = 0.44, p = .51, \eta_p^2 = .01$). However, there was an effect of book reading on receptive word learning: children performed significantly better in the animated and the static conditions as compared to the control condition ($F(1, 36) = 5.76, p = .02, \eta_p^2 = .14$). See Table 2 for descriptive statistics. None of the other vocabulary tests showed sufficient variance to carry out statistical tests.

Table 2
Descriptive Statistics on the Outcome Measures of Story Retelling and Receptive Vocabulary for Each Condition

	Animated condition <i>M</i> (<i>SD</i>)	Static condition <i>M</i> (<i>SD</i>)	Control condition <i>M</i> (<i>SD</i>)
Story retelling (number of content words recalled)	12.74 (5.75)	11.40 (6.74)	2.95 (1.86)
Receptive vocabulary test (number of correctly identified items out of three)	1.51 (0.79)	1.36 (0.81)	0.95 (0.92)

VISUAL ATTENTION TO ALL ILLUSTRATIONS IN THE BOOKS

We carried out an ANOVA with repeated measures for the percentage of total time that it took to read the book in which children fixated the illustrations of the books. Within subject factors were condition (animated versus static) and session number (first, second or third). We carried out two planned contrasts for session number: the contrast between the first and the second, and between the first and the third session in order to test whether attention to the illustrations decreased over sessions. School (school 1, 2 and 3) was entered as between-subject factor.

We found a significant main effect of condition on percentage fixations ($F(1, 32) = 19.86, p < .001, \eta_p^2 = .38$), meaning that children attended the screen more in the animated as compared to the static condition. Contrasts showed that children attended the screen less during the second session as compared to the first ($F(1, 32) = 18.56, p < .001, \eta_p^2 = .37$) but visual attention was similar in the third session as compared to the first ($F(1, 32) = 0.04, p = .84, \eta_p^2 = .001$). See Table 3 for descriptive statistics.

The same analysis was applied to the average duration of fixations on the illustrations. We found a main effect of condition ($F(1, 32) = 5.64, p = .03, \eta_p^2 = .15$), showing that fixations on the illustrations in the animated books were longer as compared to the fixations on illustrations in static books. There was no difference between the first and the second session ($F(1, 32) = 1.31, p = .26, \eta_p^2 = .04$). However, children had significantly longer average fixations on the third as compared to the first session ($F(1, 32) = 5.95, p = .03, \eta_p^2 = .16$).

Table 3
Visual Attention to the Illustrations in Animated and Static Books during the First, Second and Third Session

	Animated condition <i>M</i> (<i>SD</i>)	Static condition <i>M</i> (<i>SD</i>)
Total fixation time on the illustrations, corrected for the length of the book (in percentages) ^a		
Session 1	.84 (.07)	.79 (.07)
Session 2	.82 (.08)	.77 (.09)
Session 3	.85 (.06)	.80 (.07)
Average fixation duration on the illustrations (in seconds)		
Session 1	0.37 s (0.09)	0.34 s (0.07)
Session 2	0.38 s (0.09)	0.34 s (0.08)
Session 3	0.40 s (0.08)	0.36 s (0.06)

Note. ^a Percentage score, children's total fixation time at the illustrations were divided by the presentation time of the book in order to correct for the slight differences between the books.

ATTENTION TO MOTION WHILE LOOKING AT THE TARGET ILLUSTRATIONS

We carried out an ANOVA with repeated measures for the percentage of total fixation time spent on the selected detail (in motion in the animated version and a still detail in the static version). Within-subject factors were condition (animated versus static) and session number (1, 2 and 3). With Tobii software we selected the same areas in both versions of the books and calculated fixation durations on these target details. These scores were divided by children's fixation duration on the whole illustration in order to control for overall elevated attention to animated illustrations. Between-subject factor was school (school 1, 2 and 3). The ANOVA resulted in a significant main effect of condition ($F(1, 32) = 19.16, p < .001, \eta_p^2 = .38$) indicating that children focused more on the details when they were in motion. The contrast between the first and the third session was not significant ($F(1, 32) = 2.72, p = .11, \eta_p^2 = .08$). However, children were more attentive to the AOIs during the first as compared to the second session ($F(1, 32) = 8.05, p < .01, \eta_p^2 = .20$). See Table 4 for descriptive statistics.

The same model was applied to children's average fixation duration while looking at the selected details. There was a significant main effect of condition ($F(1, 32) = 23.92, p < .001, \eta_p^2 = .44$), showing that children's average fixations were longer on the moving details in the animated condition as compared to the same details in the static book. Average fixation durations for the first session were not different from the second ($F(1, 32) = 0.14, p = .71, \eta_p^2 = .004$) or the third session ($F(1, 32) = 0.97, p = .33, \eta_p^2 = .03$).

Table 4
Visual Attention to the Salient Movement Depicting Non-words in the Animated and Static Condition per Session

	Animated condition <i>M (SD)</i>	Static condition <i>M (SD)</i>
Fixation time on AOIs (in percentages)		
Session 1	.80 (.08)	.70 (.12)
Session 2	.76 (.11)	.68 (.12)
Session 3	.77 (.12)	.69 (.11)
Average duration of fixations while looking at AOIs (in seconds)		
Session 1	0.38 s (0.11)	0.31 s (0.07)
Session 2	0.38 s (0.10)	0.30 s (0.08)
Session 3	0.41 s (0.12)	0.32 s (0.06)

DISCUSSION

The effects of animated illustrations on children's story language recall, word learning and visual attention during storybook reading were investigated in the present study. We found, in line with previous research (Bus et al., 2014; Takacs et al., 2015), that children recalled significantly more story language in the animated than in the static condition. However, in contrast to the second hypothesis, there was no difference between the animated and the static condition in terms of word learning. Findings also evidence that, in particular, motion in pictures attracts children's attention. Compared to how children look at static illustrations, children pay more attention to the details in motion in animated illustrations. Children seem to use different processing strategies while looking at animated and static illustrations, with a larger focus on motion in the animated illustrations. We also found that children's fixations were longer on average in the animated condition. That is, they were less inclined to explore the whole picture by jumping to different visual elements but fixate more on particular details. Motion seems to guide children's visual attention resulting in more in-depth exploration of those details in the illustration. Furthermore, there is evidence that children are more attentive when listening to the animated as compared to the static version of the storybooks. That is, children attended the screen for a longer time in total and looked away from the screen less when the illustrations were animated.

Our results corroborate the theory of Verhallen and Bus (2010) that motion in illustrations guides children's attention and thereby facilitates story comprehension. Due to motion children pay more attention to visual details that are simultaneously highlighted in the oral text. Furthermore, the longer average fixations might reflect deeper processing of the relevant details in the illustrations (Rayner, 2009). Children's eyes were moving less between the different visual elements of the animated illustration and focused more on particular details. However, the current results do not prove that better comprehension results from this different way of processing pictures. For instance, we cannot exclude that comprehension in the animated condition as compared to the static condition improved as a result of higher engagement as may be indicated by children's longer fixations on the whole book. To exclude this alternative interpretation we would need an additional condition in which, in contrast to the animated book in the current study, irrelevant parts of the pictures were animated. In that case, a general effect on children's engagement and attentiveness may remain but such stories may fail to support the match between the story text and the corresponding visualizations.

Since there were no other multimedia additions like sounds and music in the stories in the present study but only motion in the illustrations, the current findings corroborate the hypothesis that motion can elevate story comprehension and thus is a crucial part of a well-designed multimedia environment for children's storybooks (cf. Takacs et al., 2014, 2015). This is the first study, to our knowledge, that shows the effects of motion on children's visual attention. Further studies are needed to investigate the separate effects of other multimedia features like sound and music to create clear guidelines for designers of multimedia stories.

Another interesting finding of the present study is that children showed significant word learning on a receptive level after listening to the stories three times. On an expressive level there were no effects. Children hardly used the target words during story retelling or the expressive vocabulary test. They also failed to give acceptable explanations for these words. This finding is in line with previous studies showing that novel word learning starts with understanding the word in context and not until children have sufficient receptive knowledge of the word they start developing expressive knowledge after repeated exposures to the word (Smeets & Bus, 2012; Verhallen & Bus, 2010).

Children, however, did show significant word learning on a receptive level. That is, they had knowledge about the words only when they were assessed in the context of the storybooks, like in the case of the receptive vocabulary test using illustrations from the storybooks. This, again, confirms previous findings that expressive word learning does not start until children recognize the word in a familiar context (Smeets & Bus, 2012; Verhallen & Bus, 2010). In contrast, children did not perform above chance level when the test measured word knowledge outside of the context in which children encountered the novel words. Results on word learning suggest that after three repeated book readings children showed elementary knowledge of completely novel words (non-words). This might be the earliest phase of word learning: understanding a word in the context in which children encountered it previously. Transfer of this knowledge to other contexts and expressive use of the word seem to come later on with repeated exposures to the word. Similar to prior findings, we expect that especially the step from receptive to expressive knowledge is facilitated by animated books (Smeets & Bus, 2012). Results of the present study on word learning extend the literature due to the use of a novel approach, using non-words as target words in the stories thus controlling for any previous knowledge of the words.

Another result of the present study was the effect of session number on children's visual attention during the stories; that is, children were less attentive to illustrations of the stories and the moving details in the illustrations on the second repetition

in both conditions. This is most probably due to the fact that the first session was conducted at the same day as the second. Children encountered the same story a couple of minutes earlier which may explain why their attention dropped. However, children were similarly attentive to the illustrations and the motion in the animations during the third repetition as they were on the first occasion in both conditions. This pattern of results supports the idea that spreading of encounters with the same books is preferable to dense practice: a few days is better than a few minutes. What optimal lags between sessions are is a question for further research.

LIMITATIONS

The non-words in the present study were inserted in place of mostly high-frequency verbs that children are likely to understand and use. Thus, children might have not been motivated to use the novel words when retelling the story or completing sentences in the expressive vocabulary test because they already know a word for these actions. It is plausible that children's expressive word knowledge was thus underestimated in the present study. It might be better to investigate novel word learning in the context of novel actions and phenomena for which children do not yet have labels in order to better estimate expressive learning of the words.

Another limitation was the use of the static illustrations of the stories in the retellings of both the static and the animated conditions as well as in the vocabulary tests. This was decided in order for the experimenter not to be influenced by the condition when interacting with the child during retelling the story. However, this might have underestimated the effects of animated illustrations on children's recall and word learning because the same animated pictures as seen during the story might have prompted more extensive recalls and better performance on a multiple-choice test based on the illustrations of the storybook like the receptive vocabulary test in the present study.

CONCLUSIONS AND SUGGESTIONS

In sum, motion attracts visual attention and changes the way children look at illustrations. Animated illustrations that are closely matched to the story text have more potential to direct children's attention to specific details of the picture as compared to static illustrations and may thus promote dual-coding (Paivio, 2007). We expect that the focus on motion in pictures explains why they look longer at the illustrations of animated books as compared to static books although we cannot exclude that they are also more alert when illustrations are animated. Although children are attracted to animations and specifically to motion in the animations, they do not seem to be mesmerized by the visual stimuli.

These effects may only occur when the animation depicts the language of the narration. Bus et al. (2014) suggested that animations that have only decorative purposes may not add to children's story comprehension and might even interfere with learning. Such incidental animations with no direct connection to the text of the story are hypothesized to distract them from the story by posing a high cognitive load on their working memory. This hypothesis is in line with a meta-analytic finding of Höffler and Leutner (2007), showing no additional benefit of decorative animations for adults' learning as compared to a moderate effect of representational animations.

This study has important practical implications for designers and developers of electronic storybooks and for caregivers and teachers navigating on the market of children's storybooks. Animations and motion seem to be a powerful tool to direct children's attention to particular details that are meaningful from the story's point of view. It seems most plausible that well-designed animations will focus children's attention on the parts of the illustrations that depict the text of the story thus facilitating the integration of verbal information in the story and the nonverbal stimuli of animation and children's story comprehension. Consequently, high-quality electronic storybooks will utilize the benefits of animations and other multimedia features, creating congruency between the story text and the technological elements like animations.

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