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Title page

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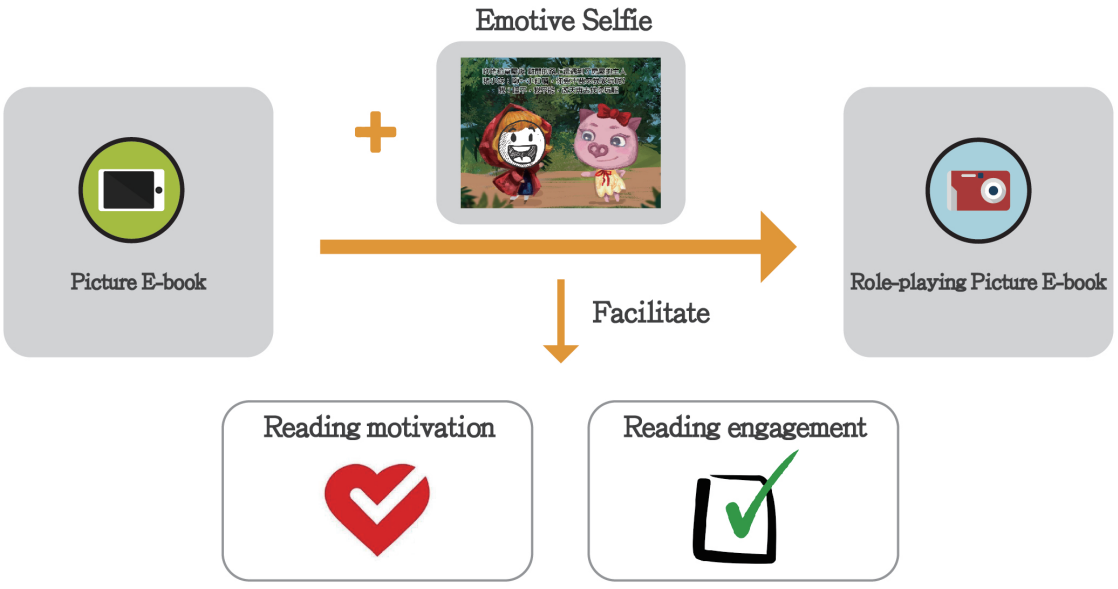

Reading behavior and the effect of embedded selfies in role-playing picture e-books: An eye-tracking investigation

Abstract

Digital and interactive media platforms, such as e-books, are becoming important tools in reading and education. In particular, picture e-books can embed multimedia effects such as sound, animation or personalized images, with potential benefits for learning and engagement. However, little is known about how such e-books are read, and most designs remain untested. In this study, an innovative type of role-playing picture e-book entitled “The Prank in the Forest” was designed which provides three different role-playing approaches: emotive selfies that allow the reader to appear as one of the main characters and were varied according to the story development, a fixed selfie that was the same on each page, or no selfie. Sixty-five students were randomly assigned to the emotive selfie, fixed selfie, and no selfie groups. To understand students’ online reading processes, their eye movements were tracked. The results showed that the emotive selfies attracted attention to the main character and also promoted scanning between text and pictures, indicating a better integration of the written and pictorial information. The selfie design led to distinct scanpaths, and this was particularly true when emotive selfies were embedded which responded to the context. Self-report questionnaires of reading motivation and engagement demonstrated that this condition was also the most engaging design for readers. We conclude that emotive selfies can boost reading engagement since they encourage the reader to observe the development of the story from the role he/she chose to play, and we discuss how embodying the reader within the graphics can enhance role-play activities with the potential for improved educational outcomes. We suggest this emotive selfie role-playing design could be applied in e-book user interfaces to create more interaction and personal meaning for the readers.

Keywords: evaluation of CAL systems; improving classroom teaching; media in education; teaching/learning strategies

1. Introduction

Literacy is not only one’s ability to read and write. It is also the basis for learning other subjects, and is an essential ability for individuals to understand the information they might retrieve from the Internet. In this era of rapid development of online information and digital media, digital reading on different media platforms has

become one of the major ways of receiving information (Zickuhr & Lee, 2014). When faced with numerous and fragmentary reading sources, learners tend to lose interest or may not focus appropriately on reading. For example, Liu (2010) pointed out that in a digital reading environment, readers tend to spend less time on in-depth reading and concentrated reading. Therefore, good reading strategies or interactive designs are needed to help learners to read more effectively and efficiently (Hyman, Moser, & Segala, 2014). It is essential to propose new interactive designs and investigate their effects on enhancing reading motivation or reading concentration in the era of digital reading.

Past studies have indicated that learners become immersed in the reading environment when they are reading for curiosity, reading for engagement, and reading for particular challenges. Reading for engagement means that readers read an interesting and quality book and thus feel able to concentrate and are satisfied (Gambrell, 2011; Wang & Guthrie, 2004). Therefore, "reading engagement" is one of the crucial elements of successful reading. Gambrell (2011, p. 173) proposed seven principles for improving reading engagement, including providing learners with activities that "are relevant to their lives." Mangen and Van der Weel (2016) also proposed that personal meaningfulness is an important element to increase motivation for reading. Through relevant or personally meaningful reading activities, learners can have opportunities to engage in sustained reading and to socially interact with others about the text that they are reading.

Picture e-books are an increasingly popular kind of reading material that may embed various multimedia effects such as sound and animation effects (Hawkins, 2000; Van Kraayenoord & Paris, 1996). In addition to arousing readers' interest through pictures, such e-books also contain interactive features such as recitation, animation, or full-text searching, which further extend the capability of paper-based picture books (Morgan, 2013; Roskos, Brueck, & Widman, 2009). However, even though picture e-books have many advantages, some researchers have proposed that multimedia effects might cause distraction from the reading process, and therefore interrupt learners' reading flow and engagement (Sargeant, 2015; Jorge, Cybis, & Matos, 2014; Yokata & Teale, 2014; Sargeant, 2013). In order to make reading "relevant to learners' lives" (Gambrell, 2011) to improve reading engagement, this study proposes the innovative use of selfies in a role-playing picture e-book. We investigate the reading process and the effects of this innovation on reader behavior and engagement. We are interested in reading and learning at all levels, and e-books are relevant across age groups. In the present study we focus on university students.

1.1. Incorporating role-playing with selfies in the e-book reading process

Generally speaking, reading is a static activity. For example, learners read materials assigned by instructors to acquire knowledge. Learners with high reading motivation are able to gain pleasure or a sense of accomplishment during their reading process. However, learners with low reading motivation might find reading a rather boring or unattractive activity (Grant, 2004; Grimshaw, Dungworth, McKnight, & Morris, 2007). Therefore, one main question in cultivating reading literacy or improving reading achievement is how to enhance learners' reading motivation. Nowadays, e-book reading is a popular way to enhance reading motivation, through the use of interactive multimedia effects (Korat & Shamir, 2007; Korat & Shamir, 2008). However, many studies have pointed out that if multimedia effects (such as hotspots and graphic animations) are not applied properly, they might become an obstacle to the reading process (e.g., distracting reader from the story, interrupting the flow of the story, decreasing reading comprehension, or inducing cognitive overload; Schugar, Smith, & Schugar, 2013; Takacs, Swart, & Bus, 2015). Accordingly, instructors should pay attention to the utilization of interactive picture e-book features while designing content or activities (Sargeant, 2015; Yokata & Teale, 2014). Many studies about interactive picture e-books have proposed that content-related interactive design can effectively enhance reading motivation and achievement (Hyman, Moser, & Segala, 2014; Kao, Tsai, Liu, & Yang, 2016; Woody, Daniel, & Baker, 2010). For example, Kao, Tsai, Liu, and Yang (2016) indicated that providing proper guidance, prompts, and feedback which are related to or coherent with the story content can effectively enhance learners' reading motivation and story comprehension.

In order to increase the level of interactivity in learning, one approach is to let learners participate in activities such as role-playing. Role-playing is a pedagogical method which can enhance learners' sense of engagement and participation. Role-playing can help learners feel immersed in a situation more easily, enhancing their motivation, and therefore improving their learning outcomes (Peterson, 2010; Shapiro & Leopold, 2012). For instance, Kalidas (2014) let learners join theatrical activities in groups. They found that role-playing is helpful for learners' expression, learning achievement and teamwork skills. In order to increase reading engagement, this study attempts to incorporate role-playing activities into an e-book design, to make reading activities relevant to the readers themselves (Gambrell, 2011) and create personal meaningfulness for the readers (Mangen & Van der Weel, 2016). In the past, role-playing activities were often performed on the stage or in the theater, and the interactive dialogue and vivid expression of the characters greatly contributed to the

success of their engagement with the role (Tombak, 2014).

In the process of designing this study's "role-playing e-book," knowing that readers would not have many body movements or gestures using the limited interactive features of e-book reading devices (e.g., iPads), we came up with a design to allow readers to express different emotional reactions to different scenes in the story by using the photo-taking functions of the reading devices. Through these photo-taking functions, readers can use their selfies to role-play the main characters in the story which might encourage them to be more involved in reading. A selfie is a self-portrait photo (Qiu, Lu, Yang, Qu, & Zhu, 2015). Some studies have pointed out that the action of taking a selfie indicates the desire for self-identity (Hancock & Toma, 2009; Nadkarni & Hofmann, 2012). Taking selfies for the story characters might help to build or enforce relationships between the readers and the characters. Furthermore, there is already some evidence that selfies can enhance learners' learning achievement and engagement. For example, in a pedagogical study on Economics, students were asked to integrate their selfies into their assignments. They could review their consuming behavior in daily life from their personal perspective and build up a relationship between themselves and the economic concepts in the textbook. This was associated with better performance and engagement in economics (Al-Bahrani, Holder, Moryl, Murphy, & Patel, 2016). A recent study also found that travel photos combined with selfies are more interesting than normal travel photos, perhaps because they enhance attention to and engagement with the photo (Dinhopl & Gretzel, 2016; Lyu, 2016).

This study proposes an innovative, role-playing picture e-book design, which allows learners to take a selfie with their camera-equipped tablet and to merge their selfie into the image of the role that they choose to play. Recent studies indicate that selfies enhance individuals' affirmation and identification with a role, and that they are an innovative mode of self-expression for young people aged 18 to 25 (Hancock & Toma, 2009; Nadkarni & Hofmann, 2012; Watson, Smith, & Driver, 2006). In a role-playing activity, the emotional expression of the characters should also be considered. Traditionally, dialogue and staging help actors or actresses to develop their sentiments and to engage in role-playing processes (Tombak, 2014). In Kalidas (2014), it was learners' engagement in emotional role-playing which enhanced their confidence and performance. Thus, in the present study, as well as using simple selfies, we designed "emotive" selfies to encourage learners to play the role with multiple and appropriate emotions. By focusing users' attention on the role that they played, they will feel more related to the characters. With the Emotive Selfie approach, the connections between learners and the story plots should be further enhanced. Learners

can take a selfie with the proper emotional expressions which match the development of the story and their interpretation of the character's inner world. We hoped that this would arouse learners' reading motivation and enhance their reading engagement.

1.2 Eye-tracking, learning and multimedia reading

Research into e-book reading activities usually uses interviews or questionnaires to investigate reading performance at the end of a reading task. Therefore, they are usually unable to thoroughly evaluate learners' reading processes in real time (Muir, & Hawes, 2013; Muir, Veale, & Nichol, 2009). Some researchers have adopted a think-aloud protocol to understand students' reading, but students might not be able to think aloud fluently or in a way that accurately reflects their reading process. Eye-tracking, which can record learners' attention distributions without interrupting reading, has great advantages for analyzing learners' processes of reading and integrating textual and graphic materials (Hegarty, 2010). Indeed, eye-tracking has already been frequently used in education and learning research (Mayer, 2010; Chien, Tsai, Chen, Chang, & Chen, 2015; De Koning, Tabbers, Rikers, & Paas, 2010; Knoblich, Ohlsson, & Raney, 2001), in domains such as text reading in language learning (Ma & Li, 2015; Sharmin, Špakov, & Räihä, 2015), calculation in mathematics (Lin & Lin, 2014; Knoblich, Ohlsson, & Raney, 2001), and learning knowledge of science (Mason, Pluchino, Tornatora, & Ariasi, 2013; Tsai, Hou, Lai, Liu, & Yang, 2012; Canham & Hegarty, 2010; Schmidt-Weigand, Kohnert, & Glowalla, 2010).

Lai et al.'s (2013) meta-analysis collected and classified studies about eye-tracking and learning into seven themes including the examination of information processing, the effect of particular types of instruction and the exploration of individual differences between learners. Tsai et al. (2012) used eye-tracking technology to observe college students' eye movements when dealing with scientific multiple-choice questions. They analyzed factors that may influence the responses and the four options through fixation time to understand the subjects' visual behavioral transfer patterns. Canham and Hegarty (2010) also used eye-tracking techniques to explore junior high school students' reading processes in receiving complex Meteorological map information. They found that when students read a meteorological map, they spent more time reading the associated key information area. Yang, Chang, Chien, Chien, and Tseng (2013) investigated the learning process of undergraduates with different subject majors. They compared eye movements in response to different types of information such as words, pictures, concept maps and sheets. It was found that when students were guided by the instructor's narration,

attention distributions were mostly in the text areas rather than in the graphic area. Colliot and Jamet (2018) used eyetracking to examine the effects of adding teacher videos to e-learning content. They found that students spent 25% of the time looking at the teacher video and that this enhanced retention of the material without negative effects on motivation or cognitive load. In the context of multimedia webpages, Beymer, Orton and Russell (2007) investigated the influence of relevant pictures, and irrelevant advertisements, on text comprehension. Although there were no effects on actual comprehension, relevant pictures were looked at more often than adverts. Interestingly, the looks to the adverts had a more negative impact on the reading of the text, even though they happened less often, and were associated with readers returning to re-read content. In the present study, we were also concerned with multimedia reading involving both text and graphics, and so eye-tracking was an appropriate technique for us to more deeply probe the way that readers might be influenced by the role-playing picture e-book design.

1.3 The present study

In this study, we utilize eye-tracking to understand students' reading processes (online) and questionnaires to understand their performance after the reading task (offline) (Lin & Lin, 2014). We expected that students who used the multimedia role-playing features would engage with the e-book differently, and that this would influence their eye movements. The aims of our study were to:

1. Record and analyze the influences of different role-playing picture e-books on reading processes with eye-tracking, and 2. Understand the influences of different role-playing picture e-book approaches on learners' reading motivation and reading engagement.

According to these aims, we will answer the following research questions:

1. Do eye movements differ when learners read picture e-books using three different role-playing approaches? Specifically, we tested how attention to the main character varied when it incorporated a selfie. We measured the time spent fixating on different areas of interest and the scanpaths involved in shifting between graphics and text.
2. Do different role-playing approaches influence learners' reading motivation and engagement with the main character?

2. Method

In this study, students were randomly assigned to one of three groups: the

"Emotive Selfie" group, the "Fixed Selfie" group or the "No Selfie" Group. Each group had different access to the available functionality of our designed e-book, that is, incorporating multiple selfies, a single selfie or neither within the story content. This study aimed to explore whether these three different approaches of role-playing would have varying degrees of impact on the students' attention distribution during reading (by using the eye tracker) as well as on the students' reading motivation and reading engagement performance, assessed by using two questionnaires (Figure 1).

Insert Figure 1 about here

2.1 Pilot study

A pilot study was conducted before the present study. Eight, ninth-grade students (14-15 years old) were recruited as the participants. The procedure was mostly the same as the present study, but the reading material was different. The material used in the pilot study was mostly based on the familiar *Little Red Riding Hood* story plot. The results indicated that the Emotive Selfie group spent more time fixating the main character. We used the pilot study to refine our stimuli and design in a number of ways. For example, the graphics we want to analyze need to be non-overlapping, or it would be hard to separate them into different areas of interest for eye-tracking analyses. A potential problem in the pilot study was that the story we adopted was familiar to most of the participants. This high degree of familiarity likely had an influence on reading performance and eye movements. Therefore, we chose to design an original story for the present study.

2.2 Participants

We recruited 65 undergraduate or graduate students (18-24 years old) from different universities in northern Taiwan as the research participants. We removed the participants who had valid eye-tracking data for less than 80% of the study time, leaving a total of 46 successful participants, of whom 15 were randomly assigned to the Emotive Selfie group, another 15 to the Fixed Selfie group, and 16 to the No Selfie group. These participants had valid eye-tracking data for 93.06% of the time, demonstrating a good data collection rate.

2.3 The role-playing picture e-book "*The Prank in the Forest*"

In our pilot study, we found that the story (*"Little Red Riding Hood")* was too simple and that most of the students had a prior impression of the story and characters. Students were unlikely to gain any new insights about the over-familiar plot. Therefore, in the present study, the reading material was changed to an original story "*The Prank in the Forest,"* which was loosely based on *Little Red Riding Hood*.

Picture e-books are suitable for all ages. In this study, we designed a picture e-book for undergraduate and graduate students which emphasized the ability to reflect on and judge characters' actions in a complex way. Our chosen story subverts the stereotypical roles and asks readers to question the morality of characters' actions. For example, the wolf is not necessarily "big and bad", and students are encouraged to question their assumptions about this character. We hoped that the experience of reading this picture e-book would help readers engage more actively with the information they read and start to think from different perspectives. There are two different main characters (Ruby and Wolf) in *The Prank in the Forest* for the students to choose for role-playing. They were instructed to read from the perspective of the role that they chose. Ruby is a naughty girl who likes to do mischievous acts, while Wolf is an innocent character who is misunderstood by everyone else. In the story, these two main characters go through a series of events together, but from each character's personal viewpoint. Therefore, we designed two corresponding versions of a picture e-book from each of the two roles' different narrating perspectives. For example (see Figure 2), on Page 8 of Ruby's version, Ruby found herself hungry and decided to eat the candy house belonging to another character ("Pig Brother"). She murmured "The candy house is so yummy." On the other hand, on Page 8 of Wolf's version, Wolf found that he was too late to catch Ruby. Ruby disappeared again. Wolf shouted "Ruby, where are you? Come out!" The story ending is intentionally designed as open-ended, providing space for students to imagine and discuss possible endings by themselves.

Insert Figure 2 about here

In order to encourage learners to devote more attention to the story, this study proposes an innovative role-playing process. This involved using readers' own selfies for the main characters. To achieve this purpose, the faces of the main characters were replaced with selfies in the first two groups, but remained as drawing portraits in the no selfie mode. There were therefore two different story versions either from Ruby's or Wolf's narrating perspective and for each version there were two modes: one with

selfies and one without. The selfie mode was used by the Emotive Selfie group and the Fixed Selfie group, while the no selfie mode was used by the No Selfie group.

The Emotive Selfie group used several selfies to replace the blank area of the main character in different scenes of the role-playing picture e-book. The facial expressions of the selfie were changed along with the development of the storyline. This means the selfie was changed regularly. For example, the main character may have been happy for two pages in a row, before changing to become angry on the third page. In contrast, the Fixed Selfie group used only one single selfie that did not change according to the story (the same image replaced the blank area of the main character in all the scenes of the role-playing picture e-book). The No Selfie group used the no selfie mode in which the original drawings of the main characters in the role-playing picture e-book were used. It should be noted here that we called all of these three conditions “role-playing reading” since in each group they could all read the story from a chosen character’s perspective, but with different access control of the selfie mechanism.

The different e-books were designed to be as similar as possible. The number of pages of both versions from different narrating perspectives was the same (16 pages). The layout of pictures and texts such as the position/portion of the main characters, the position/portion of other key graphics, and the position/number of words was taken into account. Therefore, differences in the layout of pictures and texts in the two versions of the picture e-book were constrained to a minimum in order to reduce possible interference with the eye-tracking data analyses.

2.4 Procedure (see Figure 3)

After being randomly assigned to one of the three groups, students could choose the main character they wanted to role-play: Ruby or Wolf. Students in the Emotive Selfie group were instructed to take four selfies with different facial expressions for the roles they chose to play. The students who chose to play Ruby took photos showing angry, cunning, happy, and dumbfounded expressions, while the Wolf players took selfies expressing happy, confused, surprised, and wronged (Figure 4). Meanwhile, students in the Fixed Selfie group took only one selfie with one fixed expression. These selfies were embedded into the main character portraits in the corresponding scenes in the role-playing picture e-book content. Students in the No Selfie group simply chose the role they would play. Before starting to read, the students were asked to take the reading motivation pretest questionnaire (see Section 2.7) and to go through the eye tracker calibration procedure. The main reading activity lasted for 10 minutes. Students read and turned pages at their own pace, and this

reading process was recorded with the eye tracker. After that, they completed the reading motivation posttest and reading engagement questionnaire (see Section 2.8).

Insert Figure 3 about here

Insert Figure 4 about here

2.5 Apparatus

We recorded eye movements and reading with the ASL Mobile Eye-XG, a non-intrusive portable eye tracker that can track eye movements using the principle of infrared detection of pupil position and corneal reflex. The sampling rate is 60 Hz and the accuracy of gaze direction measurement is 0.5-1°. The iPad showing the role-playing picture e-book content was held approximately 30 cm from the eyes of the participants. Participants could move their heads freely while wearing the Mobile Eye-XG and performed the required task in a natural environment setting. The system was calibrated by asking participants to fixate on a sequence of points within the field of view. The right eye of each participant was recorded. The recorded eye tracking data were wirelessly transmitted to a laptop along with video of the scene from the participant's point of view. GazeTracker for ASL was used in the follow-up data analysis to re-construct a video clip of this scene with the targets of gaze superimposed.

2.6 Eye movement measurements

Before analyzing the data, several areas of interest (AOIs) were defined in order to describe learners' visual attention (Figure 5). The text AOI referred to the area of text in the picture e-book. The main character AOI referred to the area of the main character the participant chose to role-play. The other key graphics AOI referred to the area of other graphics excluding the main character in the scene of the story. For example, if the student chose to role-play Ruby, then Ruby would be defined as the main character AOI while other key graphics (such as Wolf, Mayor, Straw House, Candy House, Lego House, etc.) would be defined as other key graphics AOIs in this individual's data analyses. The AOI layout is shown in Figure 5. The eye-tracking indicators used in this study included Total Fixation Duration, Total Fixation Count,

Percentage of Time Fixated on different AOIs, and Number of Saccades between Text and Graphics. Percentage of Time Fixated on the Text AOI referred to the percentage of the learner's fixation duration in the text AOI divided by the total fixation duration. Number of Saccades between Text and Graphics referred to the number of gaze shifts between the text and the main character or other key graphics areas.

Insert Figure 5 about here

2.7 Reading motivation scale

We adopted the reading motivation scale revised by Yang (2012). Yang (2012) translated and revised the Motivation for Reading Questionnaire (MRQ) developed by Wigfield and Guthrie (1997), and used a Rasch model to examine the revised MRQ, reducing the number of questions from the original 54 items to 24. The revised MRQ contains questions on extrinsic motivation, intrinsic motivation, reading self-efficacy and social factors. For example, two items from this questionnaire are: (a) I talk to my friends about what I am reading, and (b) My friends sometimes tell me I am a good reader. Items are scored on a 4-point Likert scale ranging from *very similar, a little similar, a little different*, and *very different*, with corresponding scores ranging from 4 to 1. A higher score indicates a higher level of reading motivation, and vice versa. For the internal consistency reliability of the scale, the Cronbach's α is .93.

2.8 Reading engagement scale

The revised overall-state measure of flow (Tsao, 2005) is used as the reading engagement scale to understand learners' degree of engagement in reading with different role-playing approaches. Tsao (2005) translated and revised this scale based on Pearce, Ainley, and Howard's (2005) "survey after the activities." The survey is an 11-item questionnaire, including measurement of "control, interest, and enjoyment" (Pearce et al., 2005). Example items from this scale include: (a) I felt in control of what I was doing during the picture e-book reading process, (b) I found reading the picture e-book enjoyable, and (c) I found reading the picture e-book interesting. Students responded using 5-point Likert scale ratings ranging from *strongly agree, agree, neutral, disagree*, and *strongly disagree*, with corresponding scores ranging from 5 to 1. A higher score indicates a higher level of reading engagement, and vice versa. The Cronbach's α for the internal consistency reliability of the scale is .77.

3. Results

3.1. General eye movement behavior in reading role-play e-books

Two corresponding versions of a picture e-book from each of the two roles' (Ruby and Wolf) different narrating perspectives were designed (see Section 2.3). Each version of the role-playing picture e-book contained 16 pages. To ensure a fair comparison, we eliminated pages that did not contain all three AOIs, and that did not have complete collected data. The eliminated pages were pages 1, 3, 7, 8, 9, 10, 14, and 16; the remaining eight pages were analyzed. We aggregated the data by summing across these eight analyzed pages and began by looking at any global differences in the number of fixations in each group (Table 1).

Insert Table 1 about here

A one-way analysis of variance (ANOVA) was carried out for each of these dependent variables. Levene's test was not statistically significant in either case, so we assumed homogeneity of variance. There was no significant effect of group on the total fixation duration ($F(2, 43) = 1.58$, $p > .05$) or in the total fixation count ($F(2, 43) = .91$, $p > .05$). Readers of these three groups showed similar total fixation time and count in reading the role-play e-books, perhaps because all read the same number of pages within the same time limit, even with different access to the selfie mechanism. Our subsequent analyses investigated whether learners in the Emotive Selfie, Fixed Selfie, or No Selfie group read differently and the possibility of more nuanced effects on how each page was inspected.

3.2. Areas of interest analyses for comparing different role-playing groups

We investigated differences in eye movements by comparing the three groups of readers. In particular, we summed the data across the eight analysed pages and examined the percentage of time that each participant spent fixating on the text, the main character and the other key graphics. In each case participant means were compared using a one-way analysis of variance (ANOVA) with the between-subjects factor of the type of selfie available. Levene's test for homogeneity of variance was not significant in each case (all $p > .05$) and there were no significant discrepancies from normality in any of the dependent variables. The results showed that there were significant differences in all three measures; follow-up post-hoc analyses were performed using LSD (Least significant difference; Table 2).

The percentage of time spent fixating on the text AOI revealed differences in the

amount of attention paid to reading between the three groups, with a large effect size ($F(2,43) = 48.19$, $p < .001$, $\eta_p^2 = 0.69$). The effect sizes for partial eta-squared were classified into small (> .01), medium (> .06) and large (> .14) (Cohen, 1988). On average, the no selfie group spent 82.42% of their time looking at the text, but this was reduced in the fixed selfie group (68.46%) and was lowest in the emotive selfie group (48.10%). Thus, selfies diverted attention away from the text, especially if they were emotive.

We expected the role-playing picture e-book to have the greatest impact on the main character which was changed by inserting a selfie of the reader. The results show that there was a significant difference among all three groups in the percentage of time spent looking at this main character, with a large effect size ($F(2,43) = 96.55$, $p < .001$, $\eta_p^2 = 0.82$). Participants in the emotive selfie condition spent the most time looking at this main character, for about one third of the viewing time (33.58%) and therefore almost as long as they spent reading the actual text on the page. Participants in the fixed selfie spent significantly less time (13.41%), but still looked at this main character more than the no selfie group did. The no selfie group only spent 5.36% of their time looking at the main character, indicating that the students might not be as interested in the character if they used the original drawing for role-playing.

Insert Table 2 about here

We also investigated the amount of time spent fixating on the other key graphics on the page. The result showed that there was a significant difference between the two selfie groups and the no selfie group with a large effect size, with the fixed and emotive selfie groups spending more of the time fixating on the other key graphics than the no selfie group did ($F(2,43) = 6.50$, $p < .01$, $\eta_p^2 = 0.23$). Apart from the main character, all of the other key graphics on the page remained the same across all modes. Therefore, differences in the number of fixations on these key graphics cannot be due to changes to the visual properties of this region, but must be due to other reading processes. This implies that the selfie mechanism might encourage students to spend more time reading other key graphics (such as other characters or the main scenery) than the group without selfies. One possible reason is that the students were engaged in role-playing the main character, so they would see the scene from the main character's viewpoint. For example, a student who was role-playing Ruby would naturally spend some time looking at the world around her.

3.3. Comparing different AOIs within each different role-playing group

To further investigate whether the selfie conditions changed the relative amount of time dedicated to the different areas of interest, we performed repeated-measures ANOVA comparisons within each group (Table 3, 4, 5). Each ANOVA compared the percentage of time spent on the text, the main character and the other key graphics.

In the emotive selfie group, participants spent more of the time on the text than on the graphics, and more time on the main character than on the other key graphics. This resulted in a significant effect of AOI, with a large effect size ($F(2, 28) = 63.0$, $p < .001$, $\eta_p^2 = 0.82$). There was also a significant effect in the fixed selfie group, with a large effect size ($F(1.19, 16.64) = 117.15$, $p < .001$, $\eta_p^2 = 0.89$). However, in this group, in addition to spending more of the time on the text, participants looked more at the other key graphics than the main character with the fixed selfie, indicating that the fixed selfie did not change students' interest to the same degree as emotive selfies. Finally, there was a significant effect in the no selfie group, with a large effect size ($F(1.06, 15.96) = 468.4$, $p < .001$, $\eta_p^2 = 0.97$), confirming that on average participants spent the most time looking at the text but also that, in the absence of any manipulations, the other key graphics received more attention than the main character. Therefore, all three groups spent substantial time reading the text; the possible reason is that they still need to understand the development of the story from the text itself no matter under which role-playing mechanism. However, it is quite striking that the emotive selfie group was the only condition where participants spent considerably more time looking at the main character than at the other key graphics, indicating that changing emotions according to the story plot did improve students' interest in role-playing the main character.

Insert Table 3 about here

Insert Table 4 about here

Insert Table 5 about here

3.4. Sequential scanpaths when viewing e-book graphics

Figure 6 gives examples of the way that participants in each group scanned one of the pages (page 12) in the e-book. Circles indicate fixations, with fixation order and duration (in seconds). As demonstrated in the previous analysis, participants in the no selfie group tended to look mostly at the text, making only occasional fixations on the graphics. In contrast, the participant in the emotive selfie condition made several fixations on the main character. This reader looked first at the text, before fixating on the main character, then going back to the text and then the graphics for a second time. This sort of back-and-forth suggests that this participant is integrating text and graphics more extensively than the other participants.

Insert Figure 6 about here

Figure 6 suggests that participants in the selfie groups might be making more transitions between text and images, over and above their closer engagement with particular graphics. To investigate this, we accumulated this data across the eight pages and analyzed the number of gaze shifts between the text AOI and the graphics AOIs (including the main and the other key graphics areas) made by each participant. We compared the number of gaze shifts of the three different conditions using a one-way ANOVA (Table 6). Levene's test for homogeneity of variance was not significant ($p > .05$) and there were no significant discrepancies from normality in the dependent variable. There was a significant effect among groups, with a large effect size ($F(2, 43) = 22.35$, $p < .001$, $\eta_p^2 = 0.51$), showing that the different role-playing approaches affected the transitions between text and graphics. Post hoc tests demonstrated that participants in the emotive selfie condition made more transitions between text and graphic AOIs than either of the other groups. It is important to note that it would be possible to observe a greater number of fixations on the selfie in this condition without more gaze transitions (e.g., if everyone simply spent longer looking at the images at the beginning of the trial). This is not what we observed, however. Instead, participants in the emotive selfie group are not only looking at the main characters more, they are looking at them throughout reading, proceeding back and forth between text and main character/other key graphics. A number of studies have shown that scanning between elements can reflect a better integration of written and visual ideas. For example, Hegarty and Just (1993) found that readers of mechanical diagrams tended to switch between the text and the image, and that this was linked to mental model construction (and more common in more complex problems). Mason, Tornatora and Pluchino (2013) asked school pupils to read scientific material

featuring text and images. They argued that “integrative transitions” – saccades which moved attention between the text and the image – were most important for learning. In the present study, we therefore consider the greater number of transitions indicative of improved integration between text and graphics, and these may also reflect the role-playing nature of the selfie in the story.

Insert Table 6 about here

Our analysis of gaze transitions does not capture any more complex patterns of scanning between the different elements on a page. An alternative way of investigating viewing differences between conditions is to use a scanpath comparison (see Dewhurst et al., 2018; Anderson, Anderson, Kingstone, & Bischof, 2015). This method allows us to investigate patterns in the full sequence of fixations on our regions of interest.

To do so, we used the string edit distance (or Levenshtein distance) to compare people in different conditions scanning the same page. Full details of the string edit distance algorithm are given elsewhere (Foulsham & Underwood, 2008; Anderson et al., 2015). Each scanpath is represented as a string of characters (in our case, representing each gaze on a region of interest: T = text; M = main character; and K = other key graphics). Any other fixations were omitted. Two scanpaths can then be compared by calculating the number of edits (adding, removing or replacing a character) required to turn one string into the other. Figure 7 shows two simple example scanpaths. The first indicates that the observer looked at the text, followed by the other key graphics (e.g., Mayor), then looked back at the text, before looking at the main character (e.g., Wolf). This gives a sequence of TKTM. The second scanpath results in a string of TMKT. Comparing these strings requires two edits, and this is normalized over the length of the longest string and then subtracted from 1 to give a similarity index of 0.5. Strings which are completely different will have low similarity scores close to zero, while two identical strings give a score of one.

Insert Figure 7 about here

We took all of the scanpaths from one representative page (page 12) in the three different conditions (1 scanpath in the no selfie group was missing; therefore, there

was a total of 45 sequences, with a mean length of 5) and compared them against each other. In particular, we examined the similarity between strings in one group with those in the other groups (a total of 3 sets of comparisons: the emotive selfie group vs. the fixed selfie group, the emotive selfie group vs. the no selfie group, and the fixed selfie group vs. the no selfie group). We then examined the average similarity of each set of comparisons, using a one-way ANOVA, to determine which scanning sequences were more similar to each other.

The results showed a significant effect of comparison type, with a small effect size ($F(2, 672) = 4.82$, $p < .01$, $\eta_p^2 = 0.01$; see Table 7). The lowest average similarity score was that between the emotive selfie group and the no selfie group (M = 0.38, SD = 0.14), and this comparison was significantly less similar than the comparison between the fixed selfie group and the no selfie group (M = 0.43, SD = 0.21). It was also less similar than the comparison between the two selfie groups (M = 0.40, SD = 0.16), although this difference and the remaining paired comparison was not statistically significant. This pattern of results indicates that the sequence of regions fixated in the emotive selfie condition was particularly distinct. Along with the evidence from regions of interest and transitions, it suggests that the emotive selfie condition, in particular, changed the way that people scanned the key elements on the page.

Insert Table 7 about here

3.5. Reading motivation

Table 8 shows the average post-test reading motivation scores for each group. These were compared across groups using a one-way ANCOVA, with the pre-test scores as a covariate. There was no interaction between the three groups in the post-test ($F(2, 59) = 1.80$, $p > .05$), indicating that the assumption of homogeneity of the regression slope was met. The ANCOVA result showed that there was a significant group effect, with a medium effect size ($F(2, 61) = 3.29$, $p < .05$, $\eta_p^2 = 0.10$), with participants in the emotive selfie group showing the highest average scores. Interestingly, this analysis shows that reading motivation increased when a role-playing e-book with selfies was used, but only when the inserted selfies interacted with different emotions and the storyline of the role-playing picture e-book.

Insert Table 8 about here

3.6. Reading engagement

Table 9 shows the reading engagement scores, based on the "overall state measure of flow" questionnaire. Scores were compared with a one-way ANOVA, and Levene's homogeneity of variance assumption was met ($p > .05$). The average reading engagement scores were significantly affected by the selfie manipulations group, with a large effect size ($F(2, 62) = 6.33$, $p < .01$, $\eta_p^2 = 0.17$). In this analysis, participants in both the emotive and fixed selfie groups showed higher engagement than participants in the no selfie group.

Insert Table 9 about here

Taken together, the results clearly show that e-books with integrated selfies have effects both on the visuo-cognitive processes involved in reading and on self-reported feelings of motivation and engagement. It is particularly noteworthy that, on all of these measures, the emotive selfie condition showed the most integration between text and graphics (in the eye movement measures) and the highest motivation and engagement. We propose that these effects are due to the adding of the emotive selfie to the illustration. This addition allows the learner to better integrate the elements of the story, increasing involvement and tension as they are the "main character". In Mangen and Van der Weel's (2016) multidimensional framework for reading, reading is allocation of attention resources and also an emotionally influential experience. Therefore, requiring a link between the selfie and the emotional content of the story may particularly boost engagement, allowing the reader to appreciate the atmosphere of the narrative.

4. Discussion and conclusions

The innovative role-playing picture e-book used in this study enables learners to play roles within a story via selfies. In this way, it seems to make the reading process an active and more engaging experience. It is hoped that this application of selfies can bring readers new experiences in interactive picture e-book reading. This design satisfies some of the principles of reading engagement—making personal meaningfulness from reading activities (Mangen & Van der Weel, 2016) as well as

providing learners with activities relevant to their lives and allowing them to “have ample opportunities to engage in sustained reading” (Gambrell, 2011).

To investigate learners’ attention during the reading process and identify which elements of picture e-books might be affecting this process, the current study used eye-tracking. The results showed that participants reading an e-book with selfies spent more time fixating on the main character, especially if this selfie displayed emotions consistent with the story. There was also evidence that they spent more time on other key graphics than the no selfie group, despite the fact that these graphics were identical between the versions.

The counterpoint to spending more time on the graphics is that readers in the emotional selfie condition also spent less time on the text, both in absolute terms and as a proportion of their viewing time. A potential concern, therefore, is that readers are being distracted away from the text, and that this might affect engagement and reading comprehension. Importantly, understanding an e-book typically involves looking at both the pictures and the text. This means that increased looks to the selfies or other graphics should not be seen as necessarily harmful to comprehension or reading speed. Our eyetracking results show that participants frequently look between text and images in order to understand and think about the page. In all conditions there remain a high proportion of fixations on the text. Therefore, the selfie conditions are likely encouraging readers to understand the scene by looking more at the graphics, whereas readers in the no selfie condition are more likely to return and re-read the text. Since the graphics were relevant for the task of understanding the story, readers may have been looking at them to gain extra information (e.g., about the emotions of the characters). Previous evidence suggests that looks to task-relevant images can support comprehension and do not necessarily make reading slower (Beymer, Orton & Russell, 2007). It is also possible that participants in the selfie conditions looked more at the main character merely because it was novel, changed between pages, or because they were attracted to look at themselves. However, these explanations do not seem to account for the increased looks to other graphics that were observed, and neither do they explain the increased engagement and motivation reported by readers in the selfie conditions. Future studies could include task-irrelevant selfies, and a formal test of text comprehension, in order to understand more about why the selfies were being inspected.

The emotive selfie group also made more transitions between the graphics and the text, and a scanpath comparison analysis suggested that this condition produced the most distinct eye movement patterns. This demonstrates that the embedding of

emotive selfies in a picture e-book attracts students' attention to the main characters and story details, but also that it prompts them to explore the connections between text and graphics. Mason et al., (2013) reported that "high integrators", who made the most shifts between images and text, were the best learners in an educational context. This indicates that our approach might boost integration of the ideas in the e-book and improve learning. In this respect, a selfie which changes to reflect the emotional context was the most effective.

In both the emotive and fixed selfie conditions, the role-playing activity led learners to be more deeply immersed in reading (according to the reading engagement and motivation questionnaires). This indicates that selfies improve students' engagement with reading material and make them reflect on their role and the characters. We suggest that, by giving students the chance to play roles in an innovative way, the selfies attract visual attention, making reading more engaging and also enhancing identification with a role.

The results of the reading motivation post-test showed that the reading motivation of the emotive selfie group was significantly higher than that of the no selfie group, but the reading motivation of the fixed selfie group was not significantly higher than that of the no selfie group. This indicates that merely including a selfie was not enough to improve the overall reading motivation. It may be that emotive selfies were necessary for students to experience the emotions of the role, so that they would be curious about the development of the story, and understand the situations that the main character faced. In other words, students could engage in the plots more easily when reading with emotional selfies. This would in turn allow them to integrate the graphic and textual information and thus have deeper reading motivation (Lazar, 2014; Shapiro & Leopold, 2012).

4.1. Implications, limitations, and suggestions for future research

The present study is one of the first to examine reading processes in interactive e-books. It is also one of the only studies to examine attention in multimedia stories using eye-tracking. The results showed widespread effects of the inclusion of selfies, both on how attention was distributed during reading, and on the self-reported engagement of the participants. This is excellent evidence that such innovations change the way that stories are read, and that this can boost engagement and motivation.

In this experiment we did not measure reading comprehension, and the story was not designed with this aim (unlike a more conventional educational text). In future work it would be interesting to examine if readers' comprehension is increased with higher engagement. Beymer, Orton, and Russell (2007) described the impact of different types of pictures on eye fixations on the text, but found no differences in the retention of the material. Increasing engagement and motivation is important, and we expect multimedia content, such as our selfie design, to ultimately improve comprehension. However, examining this would need a more detailed post-test (and potentially different materials).

Since our study tested undergraduate and graduate students, we remain cautious about applying the results to other age groups. Although e-books have potential to be used across all ages, it is also the case that there will be different design constraints for young and old readers. It is possible that role-play may actually be even more suitable in younger age groups, where comprehension is less dependent on reading speed. Investigating the effects of different types of role-playing on picture e-book reading comprehension could be a promising future study. It would be useful to compare the results of such a study in both child and adult readers.

While further research would be beneficial to investigate the link between what readers look at, how they engage with role-playing and other learning outcomes, it seems that including emotive selfies can have considerable benefits. As Mangen and Van der Weel (2016) have proposed in their integrative framework for reading research, interface characteristics are important in preparation for reading. Therefore, this study can provide practical insights for user interface design in picture e-books. The user-interface of traditional e-book mainly concerns how pages and text are displayed, and might also feature access to certain multimedia effects such as sounds and animations. Our results can lead to a recommendation that traditional picture e-books could be transformed into role-playing ones while embedding interactive elements such as emotive selfies (see Figure 8). The role-playing reading design used here has the potential for improved educational outcomes and could be widely applied to different academic fields such as History, English conversation in language courses, and so on, particularly in stories and case studies with a first-person narrative.

Insert Figure 8 about here

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Figure Captions

Figure 1. Research framework

Figure 2. Two versions of the role-playing picture e-book (left: Ruby's perspective, right: Wolf's perspective)

Figure 3. Research procedure

Figure 4. The Emotive Selfie group took four selfies with designated facial expressions for the roles they chose to play (Top: Ruby, Bottom: Wolf)

Figure 5. AOI layout of the role-playing picture e-book (if Ruby is chosen as the main character)

Figure 6. Scanpath examples (page 12; left: emotive selfie, middle: fixed selfie, right: no selfie)

Figure 7. Two example scanpaths, representing the sequence of areas of interest inspected in each case

Figure 8. A role-playing picture e-book design

Table Captions

Table 1. Descriptive statistics of total fixation duration and total fixation count

Table 2. ANOVA on percentage of time fixating on each AOI

Table 3. ANOVA for the Percentage Time Fixated on different AOIs, in the emotive selfie group (N = 15)

Table 4. ANOVA for the Percentage Time Fixated on different AOIs, in the fixed selfie group (N = 15)

Table 5. ANOVA for the Percentage Time Fixated on different AOIs, in the no selfie group (N = 16)

Table 6. ANOVA of Number of gaze shifts between the Text and Graphic AOIs

Table 7. ANOVA comparing the average scanpath similarity between conditions

Table 8. ANCOVA of reading motivation

Table 9. ANOVA of reading engagement

Table 1. Descriptive statistics of total fixation duration and total fixation count

Measure	Group	N	Mean	SD	Min	Max
Total fixation duration (seconds)	Emotive selfie	15	42.64	12.00	23.61	66.04
	Fixed selfie	15	38.44	17.04	17.28	87.35
	No selfie	16	34.16	10.12	16.03	55.21
Total fixation count	Emotive selfie	15	121.40	27.19	74	181
	Fixed selfie	15	110.00	34.07	58	198
	No selfie	16	107.69	28.48	56	165

Table 2. ANOVA on percentage of time fixating on each AOI

		Time spent fixating (%)				
Area of interest	Group	N	Mean	SD	*F*(2, 43)	Post hoc
Text	(1) Emotive selfie	15	48.10	7.18	48.19***	(3)>(2)>(1)
	(2) Fixed selfie	15	68.46	12.15		
	(3) No selfie	16	82.42	9.35		
Main character	(1) Emotive selfie	15	33.58	6.68	96.55***	(1)>(2)>(3)
	(2) Fixed selfie	15	13.41	6.93		
	(3) No selfie	16	5.36	3.14		
Other key graphics	(1) Emotive selfie	15	16.64	4.84	6.50**	(1), (2) > (3)
	(2) Fixed selfie	15	17.70	6.69		
	(3) No selfie	16	10.81	5.57		

*** $p < .001$, ** $p < .01$

Table 3. ANOVA for the Percentage Time Fixated on different AOIs, in the emotive selfie group (N = 15)

Source of variation	*SS*	*df*	*MS*	*F*	Post hoc
Between AOIs	7440	2	3720.1	63.0***	T > M > Other
Within AOIs	1674	42	39.9		
Subjects	21	14	1.5		
Error	1653	28	59.0		

T: text area; M: main character area

***$p < .001$

Table 4. ANOVA for the Percentage Time Fixated on different AOIs, in the fixed selfie group (N = 15)

Source of variation	*SS*	*df*	*MS*	*F*	Post hoc
Between AOIs	28124	1.19	23656.8	117.2***	T > Other > M
Within AOIs	3364	42	80.1		
Subjects	3.4	14	0.25		
Error	3361	16.6	201.9		

T: text area; M: main character area;

***$p < .001$; Within-subjects effects corrected using the Greenhouse-Geisser procedure

Table 5. ANOVA for the Percentage Time Fixated on different AOIs, in the no selfie group (N = 16)

Source of variation	*SS*	*df*	*MS*	*F*	Post hoc
Between AOIs	59179	1.06	55684.6	468.35***	T > Other > M
Within AOIs	1925	45	42.8		
Subjects	29.8	15	2.0		
Error	1895	15.9	118.9		

T: text area; M: main character area

***$p < .001$; Within-subjects effects corrected using the Greenhouse-Geisser procedure

Table 6. ANOVA of Number of gaze shifts between the Text and Graphic AOIs

Group	N	Mean	SD	$F(2, 43)$	Post hoc
(1) Emotive selfie	15	38.13	8.90	22.35***	(1)>(2)；
(2) Fixed selfie	15	22.27	8.17		(1)>(3)
(3) No selfie	16	18.50	8.75		

*** $p < .001$

Table 7. ANOVA comparing the average scanpath similarity between conditions

Comparison type	N	Mean	SD	$F(2, 672)$	Post hoc
(1) Emotive v. Fixed	225	0.40	0.16	4.82**	(3)>(2)
(2) Emotive v. no selfie	225	0.38	0.14		
(3) Fixed v. no selfie	225	0.43	0.21		

** $p < .01$

Table 8. ANCOVA of reading motivation

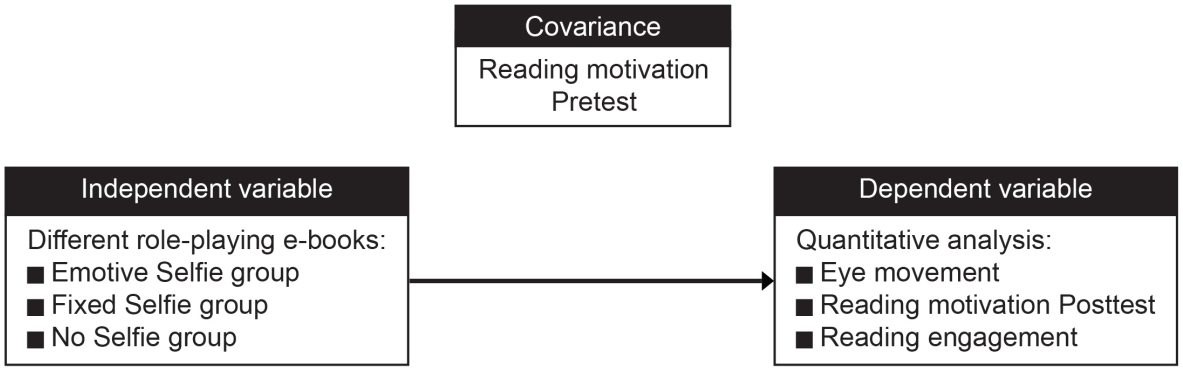
Group	N	Mean	SD	Adjusted Mean	Std. Error	*F*(2, 61)	Post hoc
(1) Emotive selfie	21	72.95	10.89	72.08	0.76	3.29*	(1)>(3)
(2) Fixed selfie	19	69.16	8.83	70.75	0.80		
(3) No selfie	25	69.92	8.20	69.44	0.70		

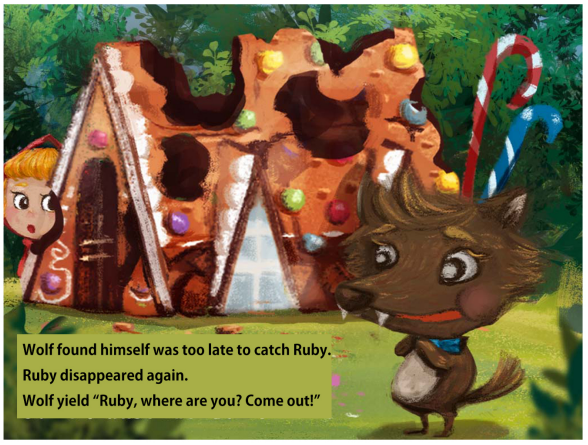
*$p < .05$

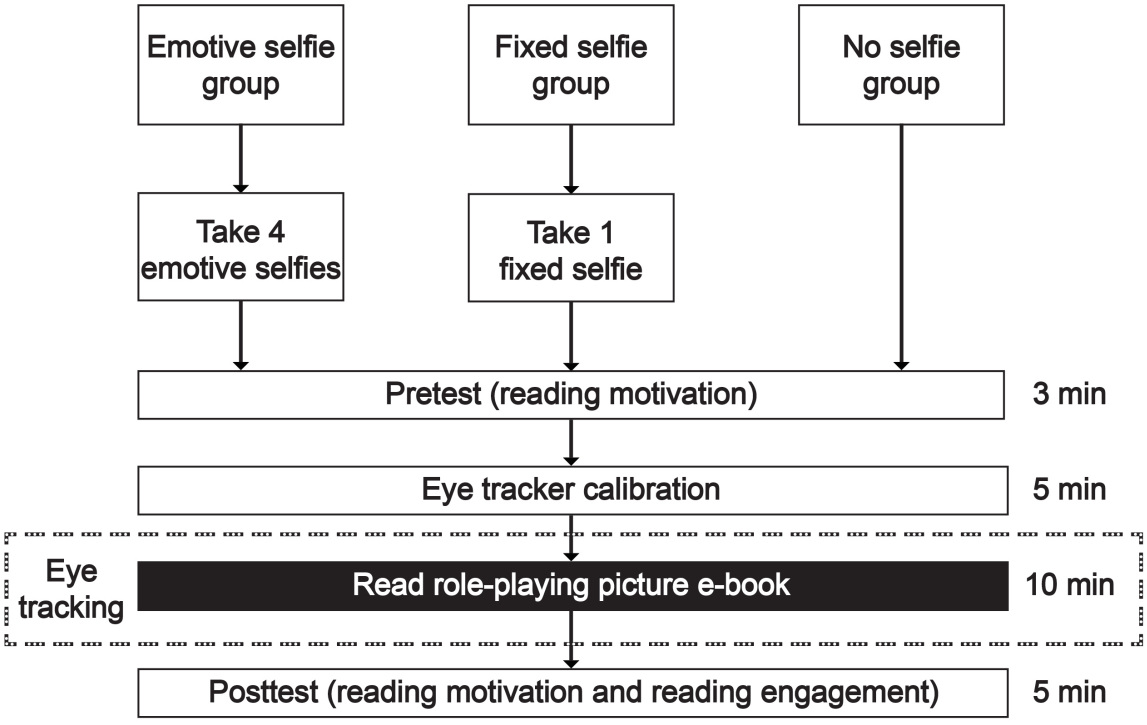
Table 9. ANOVA of reading engagement

Group	N	Mean	SD	$F(2, 62)$	Post hoc
(1) Emotive selfie	21	36.24	2.77	6.33**	(1)>(3)
(2) Fixed selfie	19	35.47	3.04		(2)>(3)
(3) No selfie	25	33.16	3.31		

**$p < .01$







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cunning

happy

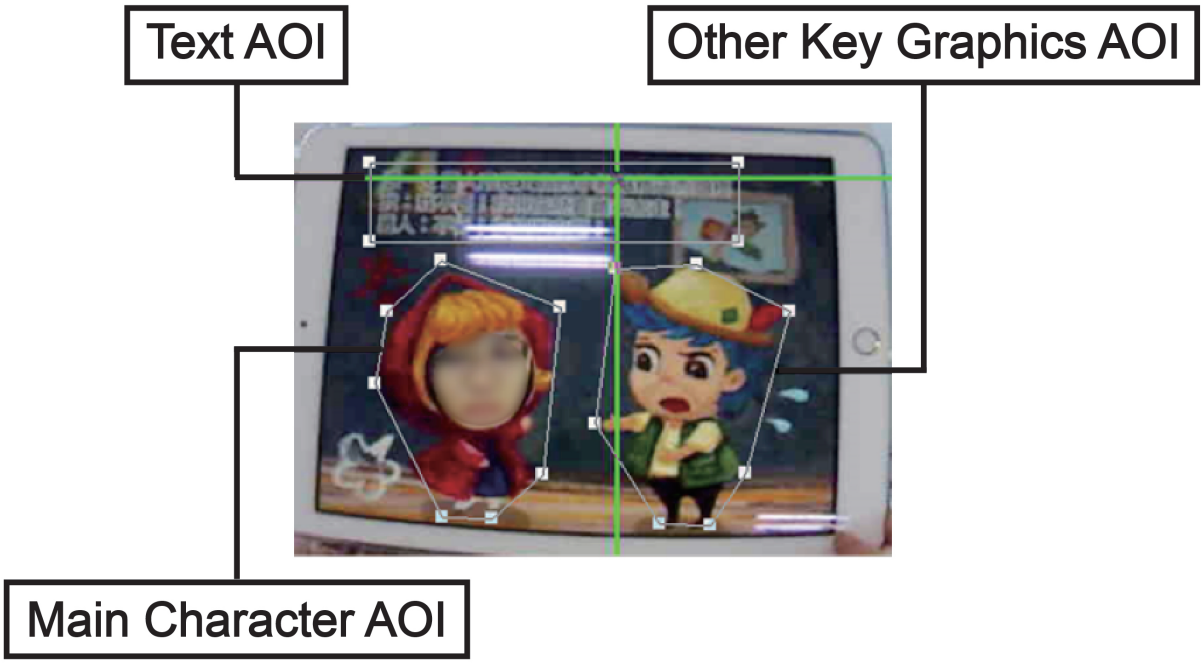
dumbfounded

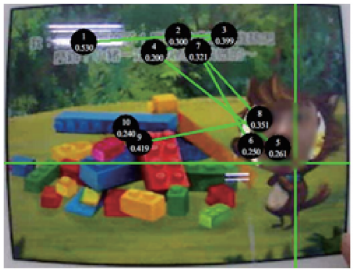
happy

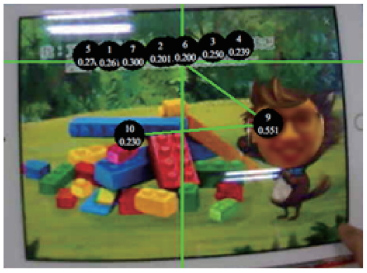
confused

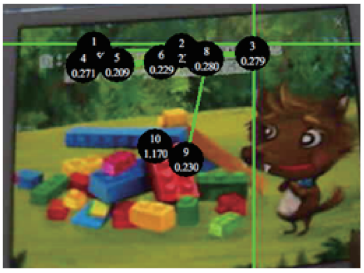
surprised

wronged



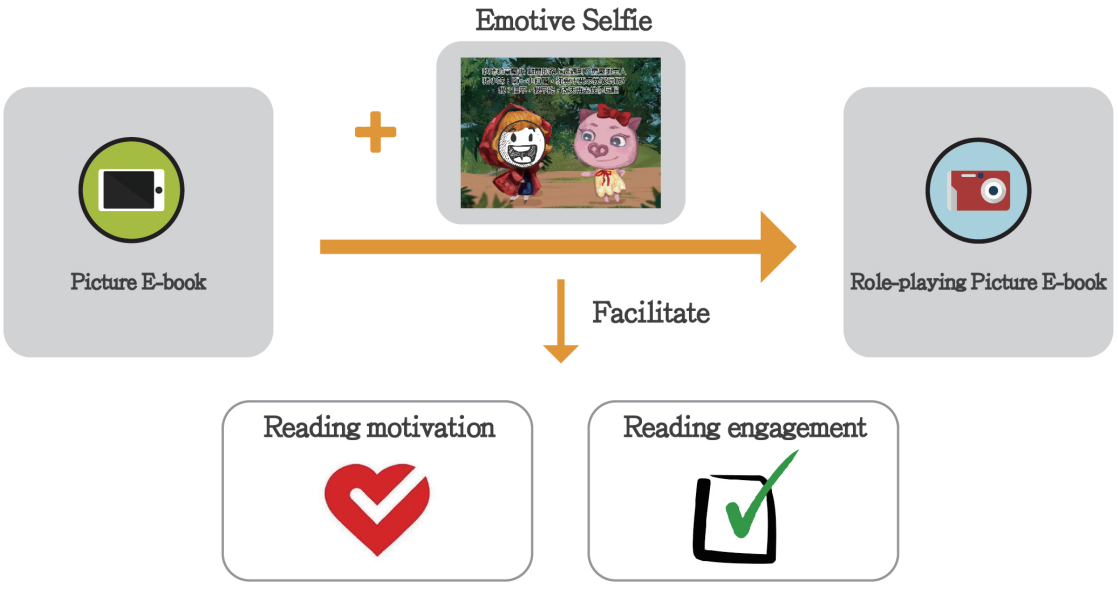






TKTM

TMKT



Highlights

- Embedding selfies within an e-book can enhance role-playing exercises
- Readers looked more at the main characters when featuring selfies
- Eye tracking also showed distinct scanpaths reflecting text-picture integration
- Including selfies boosted reader engagement and motivation
- Emotive selfies which changed with the story were most effective