Reading hotspots: a method to evaluate reader and mediator's experience with children's digital books

Lendo hotspots: um método para avaliar a experiência de leitores e mediadores com livros digitais infantis

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story apps, interaction design, reading experience, children's digital literature

One of the main reasons why children's reading is compromised in digital books are poorly designed hotspots – interaction areas. This study describes the development of a method to evaluate children's and mediators' experience while reading digital books on mobile interaction devices (MIDs). We reviewed and extended a set of metrics to assess the readers' experience through ludic approaches and data-gathering methods. Building on previous research we extended the Multimodal Analysis model. The method was validated through empirical tests with 6 dyads of parent-child involved in joint reading in a total of 18 sessions. The results corroborate the effectiveness of the method informing the design and development of children's books for MIDs.

aplicativos de histórias, design de interação, experiência de leitura, literatural infantil digital

Uma das principais razões pelas quais a leitura das crianças é prejudicada em livros digitais são os pontos de interação – hotspots – mal projetados. Este estudo descreve o desenvolvimento de um método para avaliar a experiência de crianças e mediadores ao ler livros digitais em dispositivos de interação móvel (DIMs). Revisamos e expandimos um conjunto de métricas para avaliar a experiência dos leitores por meio de e métodos de coleta de dados com abordagens lúdicas. Baseando-nos em pesquisas anteriores, ampliamos o modelo de Análise Multimodal. O método que propomos foi validado por meio de testes empíricos com 6 díades de pais e filhos envolvidos na leitura conjunta, totalizando 18 sessões. Os resultados corroboram a eficácia do método ao orientar o design e desenvolvimento de livros infantis para DIMs.

1 Introduction

Increasingly more readers are familiar with digital books due to the expansion of technological convergence (Ramos, 2017). With the popularization of Mobile Interaction Devices (MIDs), such as tablets and smartphones, storytelling apps have gained prominence as they combine children's conventional books with game design, animated videos, and other digital resources, which can significantly enhance the reader's experience (Sargeant, 2015). Introducing digital books in childhood can

facilitate the development of critical processing abilities and the creation of multimedia texts, which are crucial literacy skills in the twenty-first century (Schugar, Smith, & Schugar, 2013).

Although increasingly popular and accessible, the great part of children's digital books is designed for entertainment purposes and to keep children busy; as a result, adult participation in joint reading activities has become gradually superfluous (Follmer et al., 2012; Timpany et al., 2014). However, while digital books offer more interactive support than their printed counterparts, they cannot replace the presence of a mediator (Salmon, 2014). Furthermore, comprehension and vocabulary acquisition are more effective when adult-mediated, as adults can help maintaining the child's focus and minimize distractions from excessive or inadequately designed multimedia tools (Homer et al., 2014; Morgan, 2013). In a study with three to five-years-old children, Valaa & Takeuchi (2012) observed that 48% of parents faced challenges guiding children through the interactive areas of digital books, commonly referred to as hotspots. Researchers also voiced concerns from parents, teachers, researchers, and psychologists regarding the potential impacts of these new technologies on children's socio-cognitive development (Kucirkova, 2011).

Mediated reading, via an app or via a printed book, requires distinct approaches for conveying meaning (Hoffman & Paciga, 2014), and while apps offer more interactive opportunities, their true value needs further investigations (Timpany et al., 2014). Still, the diverse and multimodal experiences provided by these apps make it challenging to comprehensively assess their overall impact, as they influence various aspects of children's development (Kucirkova, 2011). Thus, a deeper comprehension of the "ability to produce discourses using different modes of meaning" can potentially lead to the development of better digital literature for children (Moraes, 2015, p. 240).

Outgoing from this context, this study presents a method to investigate reading between children and mediators using MIDs books, examining how and to what extent the interaction resources i.e., the hotspots present in children's digital books can either enhance or hinder the reading experience of children. We proceed by presenting a literature review on the topic, the method and the rationale behind the study, and finalize with a discussion of the results.

2 Literature review

A literature review of methods for evaluating the interaction experience with storytelling apps in mediated reading revealed that there are only few studies on the topic (Menegazzi, 2018). In a comparative study, Homer et al. (2014) assessed the learning and educational potential of a printed book, an interactive app and a "digital reading game" for the Kinect console. To assess children's emotions, the authors used emojis with happy, neutral, or sad emojis. They concluded that although the

interactive and gamified versions of the book facilitated learning, the presence of a mediator is crucial for reading development.

Kucirkova et al. (2013), investigated how iPads influence mother-daughter interactions during joint reading, and concluded that apps can offer interaction experiences like their printed counterparts due to the freedom of movement and gestures supported by MIDs. However, the authors recognized that the contributions are still initial due to the novelty of the medium (Kucirkova, 2013). The observational method and the Multimodal Analysis used in their study are promising approaches for investigating children's engagement with digital books in situations similarly related to their actual use, e.g., at home, which very few studies have explored (Kucirkova, 2013).

3 Measuring the readers' interaction experience

In Education, "mediation" derives from Lev Vygotsky's theory that emphasizes learning through language within a cultural context (Vygotsky, 1987). In Design, mediation aligns with interaction and refers to actions facilitated by artifacts or the ability to mediate relationships through them (Cardoso, 2013). In User-Centered Design, interaction with products emphasizes not just usability, but also emotional resonance in its use (Norman, 2003). Research in User Experience delves into the phenomenological and pragmatic aspects, exploring ways to enhance user satisfaction (Hassenzahl et al., 2000).

To evaluate users'/readers' interaction experiences with children's digital books, we have delimited our investigation to the interactive areas – the hotspots. Drawing from prior work, we identified 13 hotspot types based on their functions and modes of interaction (Menegazzi, Sylla, & Padovani, 2020), see Figure 1. This framework guides our assessment of interaction experiences.

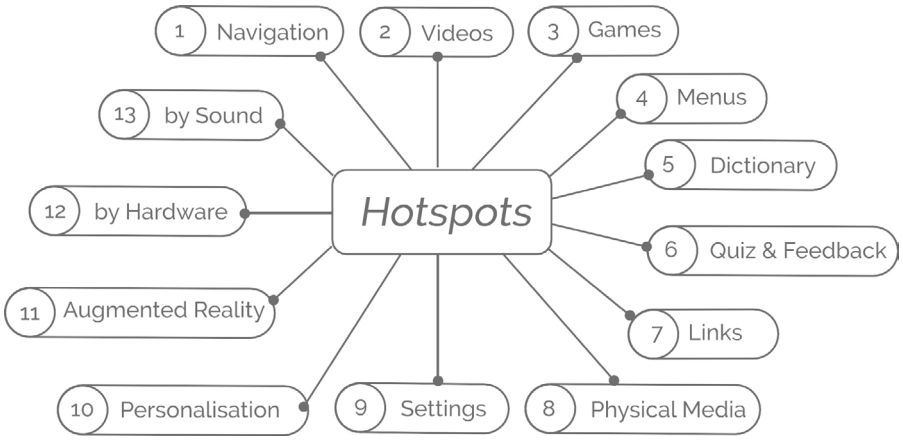

Figure 1 Different types of hotspots in story applications. Adapted from Menegazzi, Sylla & Padovani (2020).

3.1 Metrics

Building on literature review on children's interaction with digital books (Menegazzi, 2018), we identified five metrics, and main recommendations. The metrics measure positive /negative aspects using a bipolar scale of children's interaction with hotspots in story apps (see Figure 2), namely:

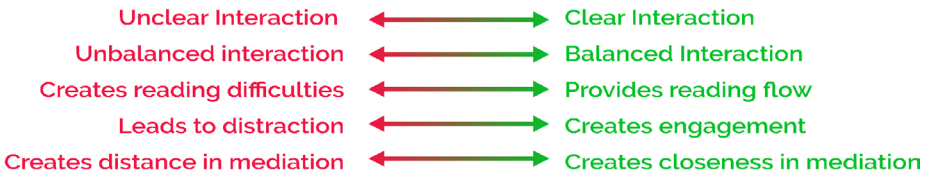

Figure 2 Metrics for evaluating user/reader interaction.

3.1.1 *Clear interaction × Unclear interaction*

This metric identifies if the hotspots and the underlying interaction during reading are clear or unclear for the user/reader. For children to benefit from these interactive books, it is important that they understand how to use the hotspots. This requires adequate representations that can have various forms such as graphic, verbal, iconic, and auditory (Cahill & Mcgill-Franzen, 2013).

3.1.2 *Unbalanced interaction × Balanced interaction*

This metric identifies if the user/reader considers the number of hotspots adequate, or if there is an imbalance due to the excess / lack of interaction areas. Although children generally prefer digital books with more interaction areas (Kao et al., 2016), excess may compromise learning due to cognitive overload caused by multitasking (Bus, Takacs, & Kegel 2015; Morgan, 2013).

3.1.3 *Creates reading difficulties × Provides reading flow*

This metric identifies if the hotspots promote fluid reading or if they hinder reading. E.g., the inclusion of interactive dictionaries and extra content may help the child to read, even when faced with unknown words, but continuous interruptions due to switching tasks may compromise the understanding of the story (Smeets & Bus, 2012).

3.1.4 Leads to distraction × Creates engagement

This metric identifies if the hotspots engage or distract the readers from the literary narrative. Well-designed, narrative-congruent hotspots result in more attractive books, higher engagement, positively influencing reading frequency that results in better learning. On the contrary, poorly designed hotspots can generate nonrelated play, interrupt reading, distract and impair understanding (Cahill & Mcgill-Franzen, 2013; Kao et al., 2016; Salmon, 2014; Timpany et al., 2014).

3.1.5 Creates distance in mediation × Creates closeness in mediation

This metric identifies if the hotspots contribute to mediation activities. Generally, hotspots are designed only for the child and not for shared reading (Timpany et al., 2014), nonetheless, some hotspots still offer possibilities for the mediator to use them together with the child (Kucirkova et al., 2013). In the following section we present the method used in this study.

3.2 Method

The investigation used the Interaction Test protocol (Cybis, 2002). The Interaction Test involves simulating usage scenarios with a sample of users that are instructed to perform typical tasks, while the evaluator observes the task execution, identifying errors, behaviors, etc. To conduct the Interaction Test, we followed the steps outlined by Cybis (2002), which include: (1) conducting a preliminary analysis to assess the suitability of the apps that are going to be tested; (2) defining the tasks and user profiles; and then (3) specifying the tests, along with data collection, analysis, and interpretation.

3.3 Selected sample of apps

We selected three story apps for children based on its availability in the Portuguese language, compatibility with children's age group and presence of different hotspots. The apps were selected from renowned children's literature awards lists, e.g., the Prêmio Jabuti,[1] and from the most popular apps in the App Store. The sample was composed of (a) *Quanto Bumbum!* (2016) and (b) *Marina está do Contra* (2018), and (c) *Monkey Hat* (2014). A preliminary analysis showed that the apps presented ten different hotspots (see Figure 3). None of them presented hotspots for dictionaries (no. 6), for integration with physical media (no. 8), or augmented reality (no. 11) (Figure 1).

1 The Prêmio Jabuti website can be accessed via the following link: https://www.premiojabuti.com.br

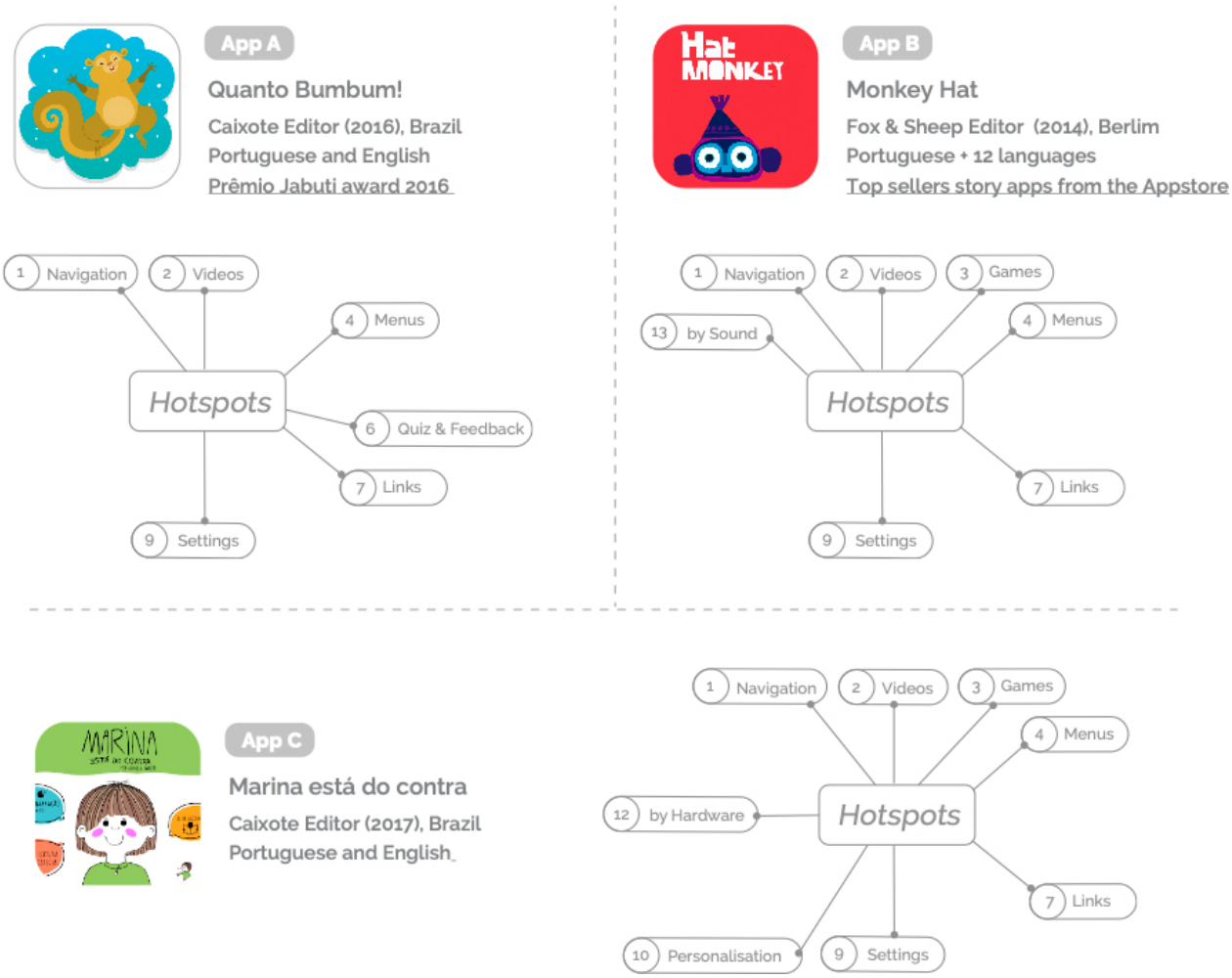

Figure 3 Graphical representation of the hotspots of the sample of children's digital books.

3.4 Instruments

3.4.1 Evaluation scale for mediators

As our study involved children and mediators, we used different instruments to evaluate their experience. Regarding the latter, we used a Likert scale, an instrument that is commonly used in design surveys with adults, and that easily allows to measure positive or negative perceptions of a product (Lucian, 2016).

We used a five-point Likert scale, since it presents the metrics' bipolar descriptors in both extremities with a neutral point in the middle. Building on recommendations from the literature (Lucian, 2016), we used word labels, as this is the most user-friendly format for interviews, when compared to labels such as numbers or graphs, facilitating ease of interpretation (Derham, 2011; Lucian, 2016). Figure 4 shows an example.

Figure 4 Likert scale with word labels for evaluation with the mediators.

3.4.2 *Evaluation scale for children*

Collecting opinions from young children is challenging. Children perceive the world differently from adults and their needs also differ (Arif & Sylla, 2013). In user studies children may have difficulties to understand questions and to express their opinions verbally (Sylla et al., 2017, p. 2). Thus, special care needs to be taken when choosing an evaluation method to access children's perceptions.

In a comparative study of survey methods with children (Sylla et al. 2019), the Paper Ladder stood out in terms of ease, pleasure, and preference in relation to other methods such as the Sticky Ladder or the Five Degrees of Happiness (Hall, Hume, & Tazzyman, 2016). The Sticky Ladder is a Velcro ladder that represents a tangible version of a Likert scale (Airey et al., 2002). Children can express their preferences by attaching items representing the products under investigation to the Velcro. The Paper Ladder is an adaptation of the latter (Sylla et al., 2017, 2018), being easier to produce and use, since the paper version favors the handling of the pieces by the children who can relocate and review their choices easily following their preference (Sylla et al. 2019). The Five Degrees of Happiness (Hall, Hume, & Tazzyman, 2016), uses emojis to evaluate children's perceptions of a product.

We used the Paper Ladder[2] available from (Sylla et al., 2017). We printed the ladder on paper and created 5 × 5 cm cards, each representing one hotspot of each type present in the apps (Figure 5).

2 The Paper Ladder model can be downloaded here: http://mobeybou.com/evaluation-tools/

Figure 5 The hotspots from app C printed on cards and the Paper Ladder method. Adapted from Sylla et al. (2017).

4 Study protocol

Before the study we administered a questionnaire to the mediators about their reading habits and familiarity with digital books and MIDs. The questionnaire provided information about the digital devices present in the family' homes, its accessibility to children and children's daily use of digital devices. We also collected data on how often they read together and if they had read any kind of digital book.

To detect possible issues, prior to the user study we conducted a pilot with one dyad following the procedure and the protocol of the study (see Figure 6).

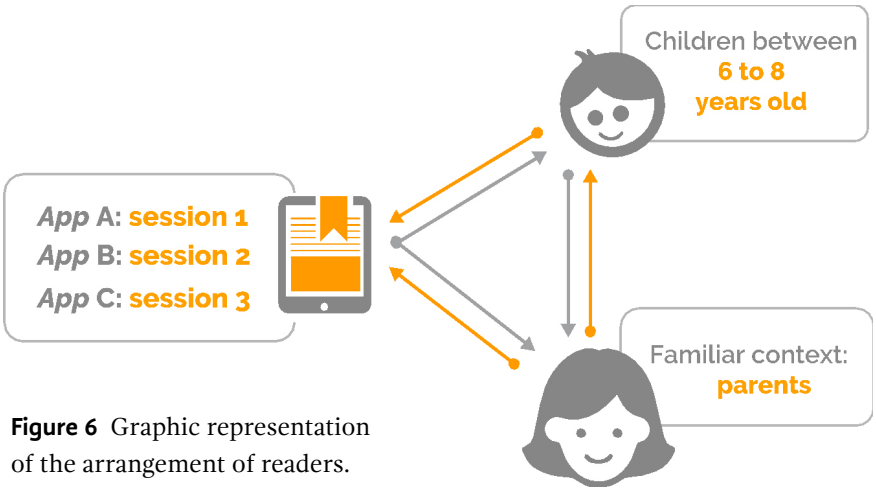

Figure 6 Graphic representation of the arrangement of readers.

4.1 Participants

The study was conducted with 6 parent-child dyads. The children were recruited in a public elementary school in Portugal and were between six and eight years old. According to the National Pact for Literacy at the Right Age in Brazil (PNAIC, 2017), this is the age range in which children acquire literacy skills, and although children already have some reading independence, the presence of a mediator is essential.

According to the questionnaire all six families had smartphones, computers, and tablets, with the latter being the most frequently used by children for up to an hour daily. Three out of the six parents (50%) engaged in daily reading with their children, one mother read once a week, and the other two did not had this practice. Only two parents reported prior experience in using digital books with their children.

4.2 Procedure

The tests were carried out at the school library after classes in the presence of a researcher. Each dyad participated in three reading sessions, with a total of 18 sessions. Each session lasted approximately 15 to

20 minutes and was carried out with each of the three apps on a different day (Figure 6). The data was collected through observation notes, and video recordings.

The child and the mediator shared a tablet and were instructed to read as they usually do at home. A researcher stood in the background observing, taking notes, and filling out a list of tasks that was defined to map and track the reading and interaction tasks. At the end of the reading, if the dyad had not interacted with a hotspot, the researcher asked them to perform specific tasks to cover all the interactive areas of the app (see Figure 7).

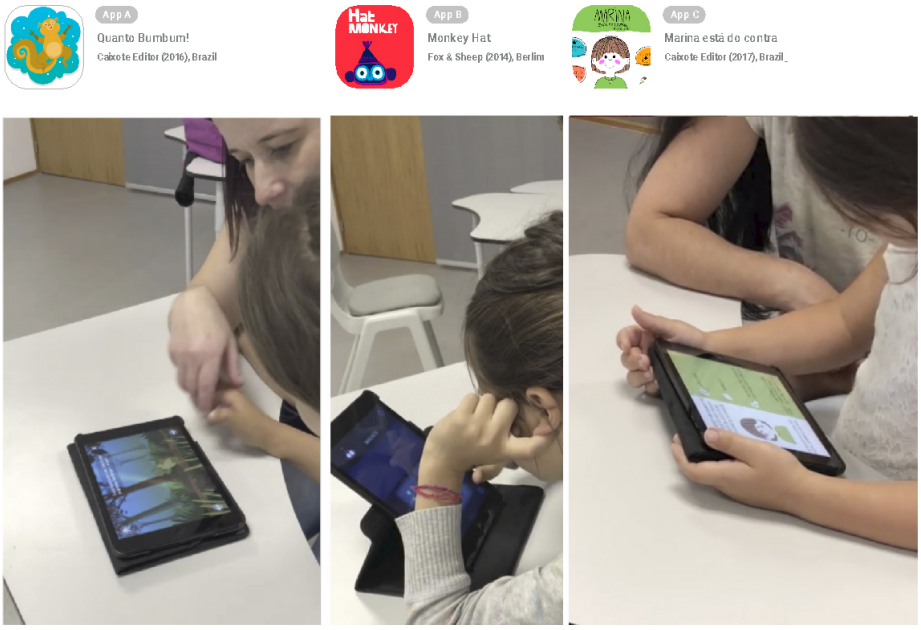

Figure 7 A parent-child dyad interacting with 3 different story applications.

5 Assessing children's experience

At the end of each intervention, we asked each child about their experience using the Paper Ladder (Sylla et al., 2017). They began by identifying each printed card, say what it represented, its function and how to interact with it (Figure 6). Then we asked her to position each card/hotspot on the Paper Ladder, explaining that the higher the step of the ladder, the more the child had enjoyed interacting with that hotspot. For each printed card, we also posed questions based on the metrics and requested the child to place the same card on the Paper Ladder. The data was collected though observation notes and photographs of the arrangement of cards positioned by the child on the Paper Ladder.

5.1 Assessing the mediator's experience

We then invited the mother to complete a Likert form for each hotspot based on the applied metrics (Figure 2). We used the printed cards and asked the mediator to first identify and then evaluate each different hotspot. We also asked the mother to evaluate her daughter's interactive reading experience and her own. The flowchart (Figure 8) gives an overview of the procedures for user selection and data collection.

Figure 8 Flowchart of research procedures with users/readers.

6 Results

The data was analyzed following a mixed method, i.e., we used Multimodal Analysis as a qualitative method to evaluate the interaction between the child and the mediator during the interactive reading, and Cross-checking Data as a quali-quantitative method to analyze and compare the responses gathered with the Likert scale and the Paper Ladder.

6.1 Multimodal Analysis

Building on Kucirkova et al. (2013), we chose the Multimodal Analysis as evaluation method. Multimodal Analysis deviates from studies traditionally focused on verbal language by encompassing gestures, body and head position, movement, gaze direction, proxemic relationships among social actors, artifacts, and their spatial arrangement (Flewitt, 2012). As story apps are digital texts and encompass intricate amalgamations of words, images, videos, etc., (Flewitt, 2012) Multimodal Analysis offers a very comprehensive evaluation method. We employed observation notes and recordings following the video analysis model (Figure 9) proposed by Kucirkova et al. (2013), as well as the multimodal transcription framework (Flewitt, 2012).

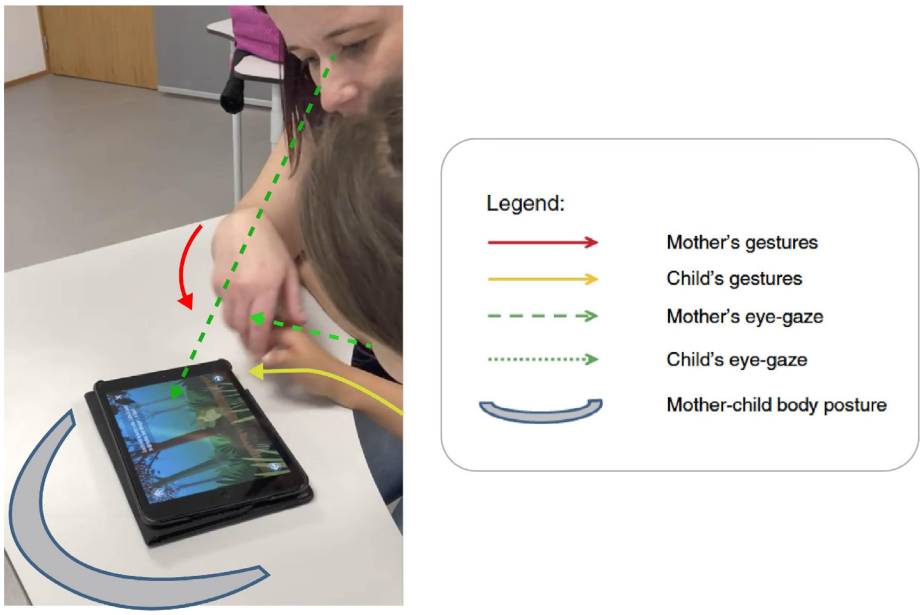

Figure 9 Multimodal analysis of video recordings. Based on Kucirkova et al. (2013).

Figure 10 presents an extract from the multimodal transcription carried out with one dyad.

Participants: Mother, daughter (7 years old) reading 1 – App (a): Quanto Bumbum. Users had smartphone, tablet, computer, and video games at home. The child has access to tablet and computer for up to 2 hours daily. They usually read books together once or twice a week. They had never read digital books together.

6.2 Cross-checking data

The data from the child's experience, collected through the Paper Ladder, and from the adult mediator, collected through the Likert scale, were quantitatively tabulated using the mean formula and qualitatively analyzed according to the proposed metrics.

The pilot allowed us to identify some issues in the developed method, particularly concerning data collection:

We found that the 'Interaction clear vs. interaction unclear' metric needed to be split into two questions to assess the difficulty in (i) locating the hotspots and (ii) understanding how to interact with them. Thus, this metric was expanded and further detailed in a corrected form (Figure 11). The other metrics showed no problems.

The pilot also unveiled resistance in the initial research session due to child shyness and unfamiliarity with interacting on MIDs, therefore we varied the order in which the apps were presented for reading.

All children and parents voiced that interactive gamified areas engaged them in more active participation.

Micro actions		Body posture	Look	Gestures	Speech
1	Mediator (mother)	Sits as if hugging her daughter, holds the tablet with one hand throughout the reading.	Alternating between daughter and tablet.	With the other hand the mother tells the daughter where to interact with the book to start reading.	"This one must be for reading."
2	Daughter	Sits next to her mother, uses only one hand to interact with the tablet. Is very shy.	Focuses on the tablet but is also guided by the hand of her mother who gestures to the interface.	Keeps index finger close to the tablet, but only starts to interact after mother's indication	—
3	Daughter	Gets closer to the tablet to start reading	Fixed on the tablet.	Keeps her hand close to the tablet, but without interaction.	Reads the first page aloud.
4	Daughter	= Micro action 2	Looks to the graphic interaction track of the book (video hotspot) and then to her mother with doubt.	Touches the animated area (circles) that are over a character. But the proximity of this hotspot with the "home" button (hotspot navigation) causes them to return to menu.	—
5	Mother	= Micro action 1	Directed to the tablet.	Indicates to her child to touch the button to restart the reading.	—
6	Daughter	= Micro action 2	Follows the indication of her mother and then presses the button to go to the next page.	Taps the forward page button and then avoids touching any other area of the book.	Reads the following pages aloud without difficulty.
7	Daughter and Mother	= Micro action 1 and 2	They look at the tablet which, at page transitions, generates a black screen and takes time to load, then they look at the researcher, confused.	Points to the dark screen of the tablet.	They both ask: "Did it turn off?" The researcher answers that it is how it works, and they return to the activity.
8	Mother	= Micro action 1	Looks at the researcher.	Points to the tablet asking for help, but they continue to handle it and, as soon as the page loads, she returns to activity with her daughter.	They say they finished reading and ask if they should do anything else. Girl asks what the animated circles were and what the "T" button (enable/disable the text) was for.
9	Mother	= Micro action 1	Alternates between her daughter and the tablet and smiles when they discover the animations.	Tells the daughter to click on the circles that fire animations and other resources in the book. This starts the book again.	"What does this one do?" "And this one?"
10	Daughter	= Micro action 2	Looks at the tablet and, after interacting with animations, look at her mother and smiles at the discovery.	No gestures, just waiting for her daughter to interact with the animations.	—

Figure 10 Example of the multimodal framework.

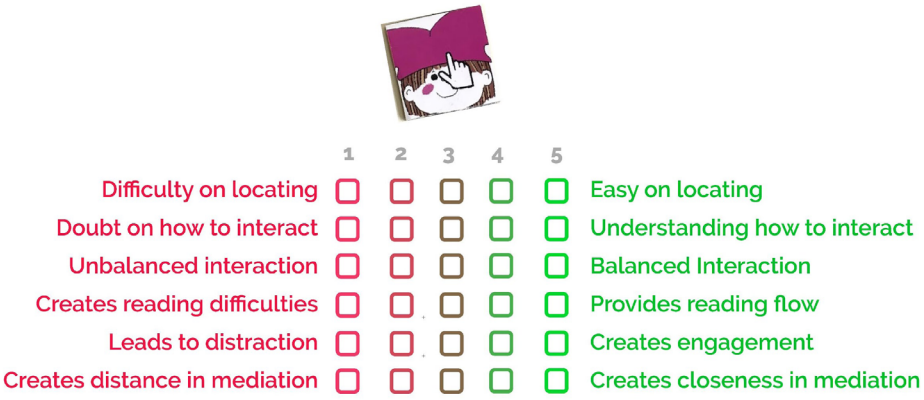

Figure 11 Representation of the hotspot of the video (app C) printed on a card and the new set of metrics.

Regarding *Clear interaction* × *Unclear interaction*, in many cases, the dyads did not interact with some interactive content, even when prompted, because they couldn't find the hotspot that triggered it during the reading. This indicates that the initial interaction challenge users face when using a story app lies in the appearance and location of the hotspots. Additionally, complex interactions require instructional prompts.

In terms of *Unbalanced interaction* × *Balanced interaction*, the main issues identified were an overload of overlapping multimedia resources in one of the apps and the predictable recurrence of the same resource in another one.

Regarding *Creates reading difficulties* × *Provides reading flow*, we observed that hotspots with more complex interactions require instructions, preferably in the form of animations presented on the same page. Support features, e.g., automatic reading mode, interactive dictionaries, or summaries, need to be easily accessible so that they can be clicked whenever necessary without the reader having to leave the page they are reading.

On the aspect *Creates distance in mediation* × *Creates closeness in mediation*, the child generally takes the control while reading/interacting with the apps. This results from the proximity and how the dyad position themselves in relation to the reading device. Parents, acting as mediators, choose or are prompted to take on the "helper" or "co-readers" role. The younger children sought the help of mediators by asking how they should read, the meaning of difficult words, or requesting the mediator to read parts of the book. The involvement between the child and the mediator was more intense when the app provided space for the children to invite the adult to assist them.

Regarding the preference for hotspots, children and parents agreed that the gamified interactive areas in which parents were invited to play along or cheer on the child during the activity triggered more active participation if they were simple and related to the narrative text, since they offered challenges that could be solved together. This reinforces the data obtained and analyzed in the metric *Leads to distraction* ×

Creates engagement aspect, according to which, animations and gamified mechanisms proposing simple challenges congruent with the story tend to engage the users more effectively than complex interactions that require prolonged or bureaucratic activities.

Cross-referencing the results, and considering the data provided by the questionnaire (Figure 12), we concluded that regular reading strengthens affective relationships and mediation, even in the context of digital reading. Most parents mentioned difficulties in locating or using literary apps, attributed to the complexity of access, and searching in virtual stores. We observed that after just three reading sessions, there was an increase in familiarity and interaction between reading children and their parent mediators with the apps, even in dyads that did not have a history of joint reading or were initially unfamiliar with digital devices.

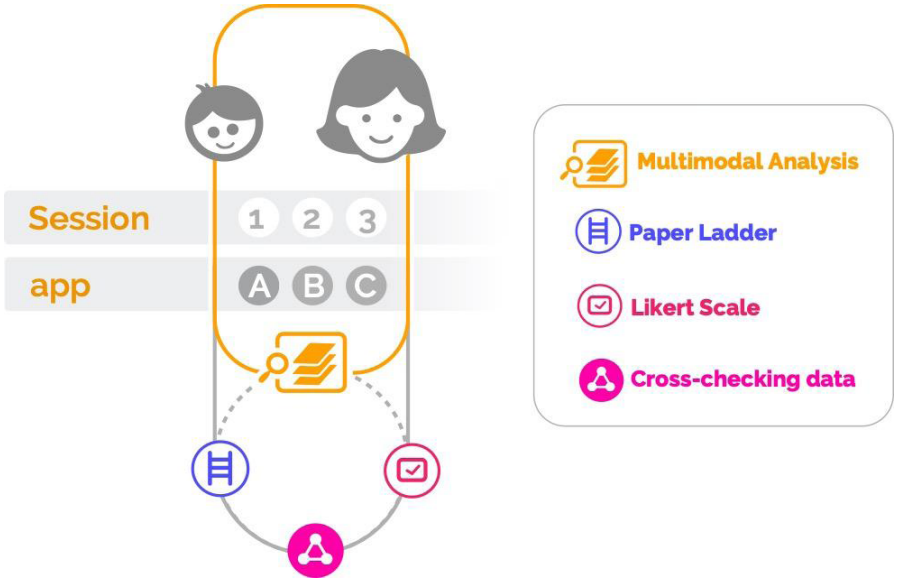

Figure 12 Flowchart of the evaluation and analysis procedures.

7 Discussion and method corrections

Despite the ease of use offered by the Paper Ladder, we faced challenges. The abundance of metric-based questions led to child fatigue. Children also had difficulties understanding the questions, often providing similar answers for questions related to the same hotspot. This was influenced by their initial choice of card position in response to the first question regarding their preference for an interactive area. To address this, we decided just to ask the child to identify each printed card's and to position it on the Ladder based on their preference. We then asked them about their choice.

Though the child was informed about the increasing values for each step, (i) they had difficulty in identifying and remembering differences between levels of the ladder, which made them position the hotspots on

the highest step when they liked, or on the lowest step when they did not like the item under evaluation, not expressing average answers. Further, (ii) the children did not understand whether the cards were positioned in the white spaces between the steps or on the steps. In addition, (iii) the printed staircase had no precise reference to where it was below or above, causing the child to question the order of the steps and their respective values. To address these issues, we incorporated a floor, and emotion labels (Hall, Hume, & Tazzyman, 2016) into the Paper Ladder. This adjustment resulted in children placing cards directly on the emojis, as validated in the subsequent interaction tests, enhancing the usability of the Paper Ladder (Figure 13).

Figure 13 Adapted Paper Ladder with the cards of hotspots of the app and emojis.

Regarding the Likert scale, we identified a discrepancy in the descriptive label, which confused mediators. E.g., the metric "*Clear interaction* × *Unclear interaction*," led mediators to select the "*Unclear interaction*" option when they meant to express some uncertainty about the interaction. In view of this, we complemented the numerical scale with emojis (Hall, Hume, & Tazzyman, 2016). These additions clarified the evaluation, aligning with Derham's (2011) assertion that a graphical scale yields superior results then a purely numerical one. Additionally, we redefined the central label point, ensuring it no longer represented a neutral value. Instead, it now signifies an intermediate value between negative and positive attitudes towards a question. This adjustment was made in accordance with Lucian's (2016) perspective that the neutral

point on the Likert scale serves to nullify the question rather than denote a supposedly completely neutral attitude.

We also varied the order of the presented apps, ensuring more consistent results. This approach proved more effective across the eighteen research sessions.

8 Conclusion and final considerations

This study aimed to address the research gap identified in the literature (Kucirkova et al., 2013; Homer et al., 2014) regarding methods for evaluating interaction and mediated reading on children's digital books.

We investigated the interaction with hotspots in digital books, which typically offer several multimedia resources. To measure the user experience, we used metrics based on previous studies (Menegazzi, 2018) and followed the Interaction Essays Protocol (Cybis, 2002). Our sample was composed of six children (aged six to eight) and six mediators that read the apps together in a school library. We adapted interview techniques, i.e., the Likert scale for mediators (Lucian, 2016; Derham, 2011), and the Paper Ladder for children (Sylla et al., 2019). Additionally, we extended the Multimodal Analysis model to systematically assess relationships and interactions with hotspots during mediated reading (Flewitt, 2012; Kucirkova et al., 2013).

Through pilot testing, we addressed data collection issues, improving the method. We then replicated and validated the method in 18 additional interaction tests.

While the study faced limitations, including a small sample size it allowed for a comprehensive investigation from the data collection to the final analysis. Despite these challenges, this research successfully achieved its objective, providing a valuable method for evaluating interaction in mediated digital book reading, informing the design and development of children's books for MIDs, and potentially contributing to the development of better literature for MID's.

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