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Language Learning with Media and Technology in (Early) Childhood[1]

Abstract:

Nowadays, from early on, children are exposed to technology and media, and six-month-olds are even expected to use some. There is a wide range of products for babies and toddlers. This article reviews the current state of the art, examining the robustness of word knowledge learned using technologies such as e-books, computer games, digital pens, and social robots, and how individual differences among children impact language learning with technology. It aligns with interactive learning theories, positing that learners need to engage in an interaction in order to construct new knowledge.

Key words:

children, language acquisition, media, technology

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Nauka języka poprzez media i technologię w okresie (wczesnego) dzieciństwa

Abstrakt:

Współcześnie dzieci już od najmłodszych lat są wystawione na działanie technologii i mediów i nawet od sześciomiesięcznych dzieci oczekuje się, że będą z nich korzystać. Istnieje szeroki wybór produktów dla niemowląt i małych dzieci. Celem niniejszego artykułu jest przegląd aktualnego stanu wiedzy oraz zbadanie poziomu znajomości słów osiągniętego przy użyciu takich technologii jak e-booki, gry komputerowe, długopisy cyfrowe i roboty społeczne oraz sposobu, w jaki indywidualne różnice między dziećmi wpływają na naukę języka za pomocą technologii. Artykuł wpisuje się w teorie interaktywnego uczenia się, według których uczniowie muszą angażować się w interakcje, aby zdobywać wiedzę.

Słowa kluczowe:

dzieci, nauka języka, media, technologia

Introduction

Nowadays, it is no longer surprising when a six-month-old child receives a book as a gift. This is because children's books offer a well-adjusted means to acquire knowledge. Below, we will review how this medium is a valuable resource for language acquisition. In addition to books, there is a wide range of products for babies and toddlers, including other forms of media such as apps for smartphones and tablets. These products introduce dynamic and multimodal elements that can foster engagement and are often advertised with the promise of benefiting children's language development, especially children's vocabulary. Reviewing the current state of the art on different technological devices, in Section 1, "Language Learning with Media and Technology: Challenging the Robustness and Transfer", we will test the promise of these products to benefit children's language by focusing on the following questions: How robustly can a novel word be learned using technologies such as an e-book, a computer game, a digital pen, or a social robot? In Section 2, "Underlying Principles of Interactivity and Scaffolding: Requiring 'Jointness' for Learning," we survey the essential principles of learning for designing effective technology; in Section 3, "Interactivity in Screen Media Usage," we examine the formats of social interaction supported by different media and technologies; in Section 4, "Individual Differences in Development Taken into Consideration by Media and Technologies," we discuss the specific affordances and constraints that address individual differences

among children. Throughout these sections, but especially in Section 2, we make explicit our theoretical position, an interactionist view on language acquisition (Rohlfing, Wrede, Vollmer & Oudeyer, 2016), which aligns with interactive learning theories positing that learners need to engage in interaction to construct new knowledge (Chi, 2009).

Language Learning with Media and Technology: Challenging the Robustness and Transfer

Many scholars emphasise that robust language learning is characterised by its ability to be transferred to other contexts, even if initially acquired in a specific one. In this regard, a central question for language learning with technology is whether children can learn language robustly from media and transfer it to real-world contexts. Additionally, since children vary in their skills, capabilities, and traits, it is important to consider which groups of children can benefit from learning with technology.

Robustness of Learning

The central question about robust learning with technology is justified, as early learning for children is embedded in social interaction and demonstrably benefits from contingent interactive behaviour. Contingent behaviour refers to the relevant and directly related behaviour of a social partner. Without social interaction, if the stimulus is limited to a visual presentation, it may have only a momentary effect and lead to a weak or impoverished memory trace. This problem is evidenced by the phenomenon referred to as the 'video deficit effect' (Anderson & Pempek, 2005), which reflects the limited ability, especially in children under 24 months of age, to transfer knowledge gained from video sources to real-life situations (Strouse & Samson, 2021).

Judy S. DeLoache (2004) discusses the question of transfer in relation to the notion of dual representation necessary for media reception. The term 'dual representation' is used with reference to images and films characterising the dual nature of their symbolic function: a depicted object, such as an apple, refers to a concrete entity in the world while also representing features of a broader category (different types of an apple or even fruits). As DeLoache suggests, the effective use of media and technology requires both notions to coexist: the medium as an object and the abstraction of its reference because it represents an entity.

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According to the dual representation approach, children learn how to cognitively process images and films during the first three years of life. For young children who have not yet grasped the idea that an object can also represent a broader category, pictures trigger the same actions as concrete objects. For instance, if children see a picture of a banana, they want to bite into it because they do not yet understand the symbolism of the picture and think the image is the object. According to DeLoache (2004), it is only when dual representation is established that children are able to see the image in its depicting function.

From the interactionist perspective, there is an alternative explanation to the empirical basis on which dual representation is grounded. It may be that by biting into a picture of a banana, it is not necessarily demonstrating a lack of symbolic representation, but rather initiating communication about the possible actions that can be performed with a banana. These actions, in turn, provide opportunities for social interaction that enrich the emergent representations. The matter is even more complicated in the context of technology when children face artificial agents. These technologies are based on children's capability to intuitively interact with them. For this, children need to treat them as if they were true partners, and they do (Oranç & Küntay, 2020). Yet, even though some technologies can simulate social interaction, recent work examining young children's transfer of what they learn from screen media to the three-dimensional world suggests that a lack of social contingency, i.e., inadequate social reciprocity, might be a primary contributor to diminished robust learning (Sommer, Slaughter, Wiles, & Nielsen, 2023). In other words, interactivity and responsiveness to children's behaviour seem to be important aspects of children's robust learning, and in the following sections, we will address them.

Transfer of Learning

If knowledge is robustly acquired, it can be transferred to other contexts (Wojcik, 2013). In investigating what benefits children in transferring their acquired knowledge from media to real-world contexts, some important research goes back to Patricia A. Ganea, Megan Bloom Pickard, and Judy S. DeLoache (2008). The authors investigated whether children can robustly learn new words with the help of different types of pictures. The results of the study indicate that children aged 15 to 18 months are capable of transferring newly learned nouns to real objects in the context of picturebooks and vice versa. However, a realistic depiction of the objects is beneficial. From this study, the authors concluded that perceptual similarity between referents

from both contexts facilitates transfer. Based on these findings, they made a recommendation for realistic illustrations to better support the purpose of language learning in early picturebooks.

A further study by Katharina J. Rohlfing and Kerstin Nachtigäller (2016), which deals with the acquisition of prepositions by 2.5-year-old German-speaking children, addresses not only the transfer but also the consolidation of acquired knowledge. In this training study, children learned new prepositions, such as *hinter* [behind] and *neben* [near to], which they had heard but not yet acquired at this age. Two central aspects determined the study design. Firstly, the study focused on the question of whether a narrative structure – characteristic of picturebook reading – provides particularly beneficial input for word learning. To this end, two groups received training with narrative structures in the form of short stories, while the control group was trained without them. The results indicate that 2.5-year-old children learn spatial prepositions best from picturebooks embedded in narrative structures. Secondly, the study compared the training materials. For this purpose, the children were divided into groups: one training group learned the spatial prepositions with the help of pictures, while the other training group was presented with the spatial relation using real objects as examples. In both groups, the new propositions were embedded in short stories about an upcoming event: "The rabbit would like to visit his neighbour. So, he hops over to the cat and the hutch. And waits directly behind the hutch to surprise her." A third control group also trained with picturebooks, but instead of hearing stories, they only received descriptive sentences: "Let's take a look at this! Here is a brown rabbit. And there is a grey cat, and this is a big hutch. And the brown rabbit is standing behind the hutch." The training of both groups was repeated several times to promote slow mapping. After the training phase, both groups were tested on both familiar and new tasks. Focusing on learning content related to spatial prepositions allowed for a comparison between two learning environments with different pragmatic demands on the children's cognitive and linguistic abilities. Learning from pictures provides children with a visual depiction of the situation and requires them to choose an appropriate scene. In contrast, when children act out with objects, there are no templates to guide them. In addition, to correctly respond to the instruction "Put the rabbit behind the hutch!," they have to check their object knowledge and abstract from the functional properties of the objects (e.g., the fact that a rabbit is usually in the hutch). This transfer task differs from the one used by Ganea, Pickard, and DeLoache (2008) for noun learning. To avoid making the transfer task too difficult, Rohlfing and Nachtigäller (2016a) used the exact same photographed objects in the picturebook context

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that were available for acting out – an aspect that, according to Ganea, Pickard, and DeLoache (2008), should give the children an advantage in learning.

The results of the study indicate that children can robustly learn prepositions from picturebooks if the new words are embedded in stories. There was also an advantage for the children who learned from stories in picturebooks: they were more successful in transferring their knowledge to objects. In contrast, the group of children who practised the new prepositions with play objects showed no ability to transfer their understanding to the picturebook context during the test. This study presents language comprehension performance as a function of the context, the tasks to be performed, and their requirements. The results clearly indicate that comprehension performance requires adaptive representations and cannot go hand in hand with the retrieval of a uniform and stable representation.

The ability to transfer word knowledge has also been investigated using more interactive technologies. Gabriella A. Strouse and Patricia A. Ganea (2017) examined 17- to 23-month-old children who learned new nouns from pictures, either in conventional books or e-books (presented on a touchscreen device). Only the children who learned from books were able to transfer their knowledge content to real objects. The transfer from e-books was only achieved by an older group of children, aged 24 to 30 months. These results clearly indicate that conventional picturebooks support the language learning of young children. They are designed in such a way that children can concentrate well on the referent without being distracted by movement, other speakers, or technical framing with further interaction possibilities.

Overall, it should be noted that the most empirical findings focus on the book-reading situation. This situation is characterised by clear roles and patterns that are predictable for children. Such clarity is not present in other situations, such as free play; therefore, the structured nature of this situation benefits language development (Rohlfing, Grimminger, & Nachtigäller, 2015). In this particular situation of book reading, Susan A. Gelman, Robet J. Chesnick, and Sandra R. Waxman (2005) observed that mothers of 2- to 3-year-old children produce a higher proportion of naming, not only pointing to objects but also elaborating on their categories, thereby fostering children's understanding of abstractness. In this way, children learn not only about the objects depicted but also about their semantic relationship to an overarching category. Pictures offer caregivers and their children a good opportunity to address the nature of things, while real objects often tempt them to address the specific features of individual objects.

Underlying Principles of Interactivity and Scaffolding: Requiring 'Jointness' for Learning

Above, we reviewed the benefits of book-reading situations for children's language development. These include not only repetitive presentations but also engaging in multimodal practices that promote interactivity. However, interactivity involves more than just enabling a contingent interaction. According to L. S. Vygotsky's (1978) theory of proximal development, social interaction with a child can be characterised in terms of scaffolding. In this process, the caregiver's goal is to temporarily support the child in tackling a specific task that they may not yet manage independently by monitoring the child and being responsive both verbally and nonverbally (Wildt & Rohlfing, 2024). Over time, this support gradually decreases as the child becomes more autonomous and able to perform the task independently, while the communicative roles of the interaction partners become more established. This way, caregivers adjust their type and level of support to align with the child's capabilities (Wood, Bruner, & Ross, 1976).

Some strategies that support the scaffolding process have been reported in the literature, one of which is asking questions to children. For instance, in a longitudinal investigation, Vivien Heller and Katharina J. Rohlfing (2017) show microanalytically that young children are initially asked to respond to the question "Where is the ball?" with a pointing gesture. Caregivers often accompany this action with an explanation, such as "Yes, that's right, there's the ball." In later interactions, open-ended questions can be asked about this referent, such as "What is happening here?," which offer the child the opportunity to determine the topic of conversation themselves and to test their narrative skills. The change in the questions, from close-ended to open-ended, underscores how an established routine creates a prerequisite for expanding the child's communicative role. Overall, the role of questions is widely recognised. According to Bridget A. Walsh and Pamela Blewitt (2006), questions stimulate children's own language production and therefore promote language development. However, as the change from close-ended to open-ended questions above suggests, questions must be adapted to the child's individual language development.

While questions are just one strategy of scaffolding, the term 'dialogic reading' summarises a number of strategies for involving children actively in reading sessions (Lonigan & Whitehurst, 1998), such as following the child's interests, giving feedback, and encouraging or expanding on the child's answers. The authors of dialogical reading introduced these strategies as part of

a training program for parents from different socioeconomic backgrounds with the purpose to support children's language skills. Rosemary Lever and Monique Sénéchal (2011) report that children exposed to dialogic reading strategies were better able to structure their narratives and decontextualise them appropriately (i.e., detach them from the immediate here and now) compared to children with little or no experience with dialogic reading. For early childhood development, it is important to emphasise that this type of reading builds on already established communicative structures of jointness, which presumably contributes to its beneficial effects. A child who does not understand their role in this particular situation with a picturebook will not be able to benefit from dialogic reading (see also Mol, Bus, Jong, & Smeets, 2008). Current findings suggest that certain communicative structures first need to be established and repeated for children to learn them (Rohlfing, Ceurremans, & Horst, 2017).

Interactivity in Screen Media Usage

In the last section, we emphasised the need for interactivity as a key property of a learning environment that adapts to the child's growing knowledge. The best way to demonstrate the property of interactivity is by examining studies on children's different ways of screen media usage. While most research studies focus on television, the effects for other screen media are likely to be similar.

Forms of Screen Media Usage

In this section, we summarise four forms of screen media usage, which differ hierarchically in their degree of interactivity and their influence on children's word learning:

Active – Through Joint Media Engagement. The terms 'co-viewing' and 'co-using,' collectively referred to as joint media engagement (Swider-Cios, Vermeij, & Sitskoorn, 2023), describe the involvement of adults in their children's interactions with media. This means, for example, that co-viewing adults support joint visual attention between young children and their remote partner in a video chat (Myers, Strouse, McClure, Keller, Neely, Stoto, & Zosh, 2024), or that parents and their children may watch a children's television program together and communicate about the content. Research (e.g., Reiser, Tessmer, & Phelps, 1984; Salomon, 1984) has demonstrated a positive influence of parental co-viewing on learning outcomes, especially for younger children. For instance, Sarah Roseberry, Kathy Hirsh-Pasek, Julia Parish-Morris, and Roberta M. Golinkoff (2009)

found that children aged 30 to 35 months only learned verbs from television programs if this context was linked to social interaction. It was not until the age of 36 months onwards that they were able to successfully acquire new verbs exclusively from the use of or the exposure to the medium. This accompaniment is beneficial for the child's "absorption of information" (Diergarten & Nieding, 2012, p. 27), as both children and adults perceive the program as an opportunity for lively verbal exchange (Lemish & Rice, 1986). The comments of caregivers help children understand the film plot and process the events. Notably young children, in particular, feel a great need to share their emotions about the events and experience an adult's interpretation. Like a book, a movie can be watched repeatedly, providing further opportunities for conversation and deepening of understanding – provided that the child has formed a general rough idea of the depicted actions with the adult in the first step. As recently highlighted by Edyta Swider-Cios, Anouk Vermeij, and Margriet M. Sitskoorn (2023), this can effectively turn screen time into an interactive and social learning experience. By actively participating in their children's interactions with media, parents can facilitate their children's deeper reasoning and help them understand and integrate what they see on screen with their real-world experiences and knowledge. However, some studies indicate that co-viewing TV with children might not elicit as rich and complex language in parents compared to shared storybook reading (Hanson, Lavigne, Gover, & Anderson, 2021). In sum, parental involvement in children's interactions with media and technology serves not only as a potential buffer against possible harms, such as exposure to inappropriate content, but also as a responsive approach to using screen media as a positive aid to children's development. This emphasises the importance of parents' active, informed, and thoughtful participation in their children's digital lives.

Active – But Without Assistance. Another form of media usage is active engagement without assistance from a human partner. Beyond its entertainment value, Anna Katharina Diergarten and Gerhild Nieding (2012) review various findings on language learning in the context of television. There is no general advantage; rather, the type of presentation determines whether children under the age of two can pick up new nouns through television. For example, when comparing learning performance across different contexts, children aged 15 to 24 months learn best in direct social interaction (see also the subsection "Robustness of Learning"). Children learn less effectively from a video where an adult addresses the learner and presents new words (a type of presentation that rarely occurs in a television program). In another study by Sarah Roseberry, Kathy Hirsh-Pasek, and Roberta M. Golinkoff (2014), children's word learning was examined across social interaction, prerecorded video, and

a Skype interaction. In the condition with the prerecorded video, 2-year-olds showed poorer acquisition of new words compared to real-life or Skype interactions. Importantly, this research highlights the value of direct engagement with the child and socially contingent interaction. Additionally, studies indicate that video chat is widely used by children under two years old (Myers, Strouse, Mc-Clure, Keller, Neely, Stoto, & Zosh, 2024) and is viewed more positively by parents compared to other types of screen media (McClure, Chentsova-Dutton, Barr, Holochwost, & Parrott, 2015). The American Academy of Pediatrics even lists video chat as an exception to its otherwise strict media limitations for children under 18 months (AAP Council on Communications and Media, 2016).

Passive – Media in the Background. Most young children prefer social interactions (e.g., Walter-Laager, Brandenberg, Tinguely, Schwarz, Pfiffner, & Moschner, 2017). However, these can be severely impaired by a television running in the background. Exposure to screen-based media refers to situations where media is played in the background – not actively watched by children – but still within their auditory and visual environment. For example, a study of 51 children aged 12, 24 and 36 months found that adults were distracted by the programs on TV and thus responded less to the children's speech. The authors concluded that having the television on in the background impairs the quality and quantity of parent–child communication (Kirkorian, Pempek, Murphy, Schmidt, & Anderson, 2009). That is, when the media is constantly playing in the background, not only may direct parent–child interaction be reduced, but parents may also be less responsive to their children's cues and less likely to engage in meaningful dialogue. This reduces children's opportunities to develop their communicative skills (Swider-Cios, Vermeij, & Sitskoorn, 2023). Not only social interaction, but also children's play experiences can be disrupted by the frequent presence of television. Background television is considered to have a disruptive influence on the development of higher cognitive functions, including language (Diergarten & Niegling, 2012). Specifically, recent research highlights that background television might create a fragmented auditory and visual environment, which can be particularly distracting for young children. This constant background noise and movement can make it difficult for children to concentrate on play or tasks that require focused attention. The interference from these distractions can disrupt a child's ability to engage deeply in learning activities or imaginative play, which are critical for cognitive development (Swider-Cios, Vermeij, & Sitskoorn, 2023).

Exposure to screen-based media often involves situations where media is played in the background – not actively watched by children, but still present within their auditory and visual environment. For example, a study of 51 children aged 12, 24, and 36 months found that adults were distracted

by the programs on TV and consequently responded less to their children's speech. The authors concluded that having the television on in the background impairs the quality and quantity of parent–child communication (Kirkorian, Pempek, Murphy, Schmidt, & Anderson, 2009).

When media is constantly playing in the background, not only may direct parent–child interaction be reduced, but parents may also be less responsive to their children's cues and less likely to engage in meaningful dialogue. This reduction in interaction diminishes children's opportunities to develop their communicative skills (Swider-Cios, Vermeij, & Sitskoorn, 2023). Furthermore, children's play experiences can also be disrupted by the frequent presence of television. Background television is considered to have a disruptive influence on the development of higher cognitive functions, including language (Diergarten & Nieding, 2012). Recent research highlights that background television may create a fragmented auditory and visual environment, which can be particularly distracting for young children. This constant background noise and movement can make it difficult for children to concentrate on play or tasks that require focused attention. Such interference can hinder a child's ability to engage deeply in learning activities or imaginative play, both of which are critical for cognitive development (Swider-Cios, Vermeij, & Sitskoorn, 2023).

Passive – Through Caregivers' Media Usage. Nowadays, television is not only consumed in the home environment but displayed on smartphones, making it transportable to any location. Movies, programs, news, and (short) videos are specifically tailored to the user's interests. It is reasonable to assume that the distraction caregivers experience through their smartphones and such content can impact their interaction with their child. Critically, children are spoken to less because their caregivers are directing their attention to the content on their smartphones rather than to them. A study by Jessa Reed, Kathy Hirsh-Pasek, and Roberta M. Golinkoff (2017) specifically examined the extent to which the process of word learning is disrupted when interaction with a child is interrupted by a phone call. Interruptions occur more frequently in interactions, and even young children can distinguish between situations where they are directly addressed and those where they are expected only to listen (e.g., Baldwin, 1993). The interruption simulated in the study took place during a learning phase and had measurable consequences: two-year-olds only learned new words when the interaction took place without interruption; if learning was interrupted by a phone call, the children did not learn any new words. The authors consider the responsiveness of caregivers to be essential and interruptions to be detrimental to the learning process.

Below, we will survey the interactive potential of media and technologies.

Television

For television, it must be clarified how programs for adults differ from those for children. Broadcasts for adults offer a visually insufficient presence of objects and a rapid flow of words that is difficult for young children to segment. They not only lack the repeated focus on the children and their abilities but also the special scaffolding structures found in social interactions. Therefore, programs designed for adults offer, at best, a poor stimulus for children's language development. The situation is different for programs designed for children as a target group. Although infants as young as two months of age show no difference in behaviour when their caregiver appears in real life or on television, infants aged four to eight months appear to respond less to television presentations that are noncontingent in response to their behaviours (Pempek & Lauricella, 2017). Many programs for children make an effort to incorporate some aspects of social interaction such as repetition of content or emotional charge (e.g., in the show *Teletubbies* broadcast in the years 1997–2001, 2015–2018, and 2022–Present) to better accommodate children. It is likely that children are able to perceive the language presented in such programs. Notably, in educational television programs for children (e.g., *Sesame Street* broadcast in the years 1969–Present), speech is designed in a child-oriented manner (Rice, Huston, Truglio, & Wright, 1990) concerning the number of words per minute, the choice of words with reference to the immediate text, the simple syntax, as well as the numerous repetitions.

In summary, there is a lack of support for a clearly positive influence of television programs specifically developed for young children on language learning. Research suggests that before the age of 22 months, children do not learn words in the context of television. However, when combined with social interaction, some programs can be appealing because they contain modified input that facilitates children's understanding in this context. Thus, children can benefit from co-viewing, i.e., when television programs are used as an opportunity to discuss content and verbally share emotions about the events depicted. This requires adults to be familiar with the content of the programs. In this context, there is evidence supporting the learning of nouns for young children from the age of 22 months and verbs for children from 36 months. Anna Katharina Diergarten and Gerhild Nieding (2012) point to a connection between children's already large vocabulary and their ability to acquire new words while watching television. Consequently, children with a smaller vocabulary are less able to benefit from this compared to their peers with a larger vocabulary.

In the literature, there is also a clear position emphasising the negative influence of television on language learning. This 'displacement hypothesis' (Neumann, 1988) predicts that the time children spend watching television is taken away from other more meaningful activities (e.g., storybook reading), thereby preventing engagement in activities essential for their motor, cognitive, and social development. It is supported by the observation that children are passive in front of a television (see "Passive – Media in the Background"). For infants, in particular, this state appears to delay language learning: Frederick J. Zimmermann, Dimitri A. Christakis, and Andrew N. Meltzoff (2007) found that between the ages of eight and 16 months, each hour of television viewing (including special educational programs for infants) was associated with a significant reduction of six to eight words in performance on the MacArthur-Bates Communicative Development Inventory (MB-CDI), which is a caregivers' survey assessing children's word knowledge. This association was absent in children aged 17 to 24 months. This negative influence has been further corroborated by Annette Sundqvist, Rachel Barr, Mikael Heimann, Ulrika Birberg-Thornberg, and Felix-Sebastian Koch (2023), who examined the relationship between children's vocabulary levels and screen media use at preverbal, early verbal, and preliterate ages longitudinally. They showed that not only did screen media use show significant continuity across the time points, but there was also a consistent negative correlation. Dimitri A. Christakis (2009) summarises that there is no evidence that television promotes language learning in children under 12 months and that more than two hours of television per day increases the likelihood of a delay in language development sixfold.

Overall, television programs specifically designed for children and tailored to their language development can be beneficial. However, these benefits are highly dependent on the amount of time children spend with the medium, highlighting the need to consider the impact of screen media on early childhood development. It is crucial to develop approaches that meaningfully engage children in joint social interactions when using screen media with young children.

E-Books and Interactive Apps

In contrast to television, which is barely interactive, the current market offers a variety of technologies and applications with varying levels of user interactivity. The diversity of available applications – some even targeting infants (e.g., Chassiakos, Radesky, Christakis, Moreno, & Cross, 2016) – poses challenges for parents and educators in determining their appropriateness and educational

value (Hirsh-Pasek, Zosh, Golinkoff, Gray, Robb, & Kaufman, 2015; Meyer, Zosh, McLaren, Robb, McCaffery, Golinkoff, & Radesky, 2021). Interactive apps often require active participation and cognitive effort from users because they require some form of contingent action on the part of the user. This active engagement is key to the cognitive stimulation benefits observed in older children when technology use is moderate (Fiorini, 2010).

A meta-analysis by Zsofia K. Takacs, Elise K. Swart, and Adriana G. Bus (2014) summarises previous experimental studies on technologies such as interactive e-books, videos, and television. The authors compared interactions with an adult to various technologies, examining their effectiveness in terms of story comprehension and word learning in children aged four to eight years. They concluded that both skills can be supported by multimedia elements in children within this age group. The support was even greater than in situations where children learned independently and unaccompanied by an adult. In this respect, the technologies can be considered similarly effective to adult guidance. However, the authors acknowledge that the media available on the market offers other interactive features (such as game elements) that may have detrimental effects, especially for specific groups of children (see below). Thus, the meta-analysis highlights the potential of technology for understanding stories and word learning, which cannot be directly transferred to available media and technologies. Another limitation of the meta-study is that other areas of development, such as socioemotional, were not the primary focus of analysis but can be of great importance for later reading motivation and attitudes.

In addition to how children perceive e-books, it is also important to consider how technology is changing caregiver–child interaction. While there is a consensus that children gain various advantages from rich verbal and affective interactions during traditional storybook reading, studies on digital storybook reading present mixed findings regarding its potential benefits (Hassinger-Das, Dore, & Zosh, 2019). Some studies found no significant differences between both formats (e.g., De Jong & Bus, 2003; Lauricella, Barr, & Calvert, 2014). For instance, no differences were observed in children's visual attention (Richter & Courage, 2017) or in the quality of parent–child interactions (Strouse, Troseth, & Stuckelman, 2023) when comparing paper and digital books. In contrast, other studies have suggested advantages for digital storybooks (e.g., Etta & Kirkorian, 2019; Strouse & Ganea, 2017). For example, Gabriella A. Strouse and Patricia A. Ganea (2017) found that e-books elicited more pointing gestures, more book-related utterances, and longer visual attention spans. Moreover, another study revealed that children learned more words from an e-book with built-in narration compared to parents reading the book

(O'Toole & Kannass, 2018). Further research indicates significant differences in information recall (Dore, Hassinger-Das, Brezack, Valladares, Paller, Vu, Golinkoff, & Hirsh-Pasek, 2018), dialogic reading (Parish-Morris, Mahajan, Hirsh-Pasek, Golinkoff, & Collins, 2013), and behaviour-, and content-related talk. More specifically, parents talked more about the book content (Chiong & DeLoache, 2012; Munzer, Miller, Weeks, Kaciroti, & Radesky, 2019), asked more story-related questions (Krcmar & Cingel, 2014), and used more distancing prompts (Parish-Morris, Mahajan, Hirsh-Pasek, Golinkoff, & Collins, 2013) when reading printed books compared to e-books. Conversely, parents asked their children fewer questions and paused less often to talk about the story when reading digital books (Wainwright, Allen, & Cain, 2020). In this vein, traditional books seem to promote content-oriented reading, whereas digital books elicit more behaviour-related talk (Parish-Morris, Mahajan, Hirsh-Pasek, Golinkoff, & Collins, 2013; Ozturk & Hill, 2018).

Similar to the displacement hypothesis (Neumann, 1988; see "Television"), critical voices describe behaviour-related talk as less important compared to content-related talk since meaningful engagement time is taken up by instructional comments (Hassinger-Das, Dore, & Zosh, 2019). Consequently, digital storybooks are viewed as less effective in supporting children's language development and literacy skills. However, a more differentiated examination of the impact of e-books on parent–child interactions reveals a complex interplay of multiple factors, such as the format and design of digital books (Clinton-Lisell, Strouse, & Langowski, 2024), individuals' familiarity with the digital medium, as well as the age of the children involved (Hassinger-Das, Dore, & Zosh, 2019).

Overall, when examining caregiver–child interaction and its impact on learning outcomes, it is crucial to consider not just the format of the book (paper versus digital) but also the features embedded in e-books. E-books can be categorised into enhanced and basic/static forms. Enhanced e-books incorporate interactive elements like voice-overs, hot spots with sounds, and animations. The effectiveness of these features varies, with some facilitating meaningful engagement by highlighting key story events (e.g., zooming in and out on the picture allows children to focus on relevant content), while others may cause distractions during reading, depending on their design (Clinton-Lisell, Strouse, & Langowski, 2024). Other explanations for the mixed findings regarding caregiver–child interaction with e-books might include experience with the digital medium and children's age (Hassinger-Das, Dore, & Zosh, 2019). More specifically, it is reasonable to assume that parents of children with little or no experience with digital books tend to focus more on the technology

and its functions rather than the book content. Moreover, younger children might get more easily distracted from the key story events by certain features compared to older children.

It seems that because e-books are designed and are not yet adaptive, their features address some children better than others. Therefore, it can be concluded that e-books and computers can be effectively used for language learning in the absence of an adult (Arnott, Palaiologou, & Gray, 2019), but their potential enfolds differently when considering children's individual development (see "Individual Differences in Development Taken into Consideration by Media and Technologies").

Digital Audio Pens

While digital formats include static and enhanced e-books as well as storybook apps, some devices can also be used in a hybrid format. A prime example of a hybrid reading medium is the digital audio pen (or digital reading pen), which combines a digital audio pen with a paper book containing pictures and text passages. Those pens are similar in appearance to ordinary pens but feature additional high-tech functions. When the reading pen is placed on a picture, symbol, or word in the book, previously recorded audio files (either sounds, words, or sentences) are played by a speaker integrated into the pen (Elsner & Jurecka, 2021). This enriches the visual input of the book with auditory information. Usually, this function is used to provide some additional explanations. However, these explanations can be coupled with different follow-up activities that can be activated by tapping on icons (e.g., Explore, Learn, Storytelling, Game). This offers children a variety of ways to engage with the book, following their own interests and preferences. Together, these audiovisual stimuli are especially helpful for young readers who are not yet familiar with reading on their own (Choi, Kang, & Sheo, 2020) or who can handle only limited text. New generations of digital pens also include the ability to to record audio files directly onto the pen and replay them as many times as desired. This feature is particularly useful for children with a multilingual background who wish to enhance those books with their own audio files in their heritage language.

In (pre)school contexts, digital pens have been shown to be particularly useful for EFL (English as a foreign language) purposes (Chen, Chen, Tan, & Lo, 2016; Choi, Kang, & Sheo, 2020; Glaser, 2018, 2022; Krish, 2020). These studies revealed that, in addition to general didactic advantages (e.g., increasing motivation, variety in methods), such pens have the potential to enhance vocabulary acquisition in English classes with older children.

In the context of family, a certain degree of interactivity gives digital pens the advantage enabling children to use them on their own, without the support from other (more competent) partners. This advantage is demonstrated by a recent study (Wildt, 2024) revealing that children as young as four years old use digital pens on their own. Thus, due to the hybrid format and the explanation function, children are able to autonomously use the pen even before they can read (Rechlitz & Lampert, 2016). Björn Rothstein (2015) also states that digital pens are a popular tool used in family and/or kindergarten contexts to build first literacy experiences. Although the digital pen is the most prevalent digital tool in children's digital home learning environment, research on how children engage with this reading medium or how caregivers verbally accompany these reading interactions is scarce (but see Wildt, 2024).

It should be noted that even though research has shown that even preschoolers can use digital pens independently, the initial stages of learning how to interact with such technology closely resemble traditional joint storybook reading practices. In traditional joint storybook reading, changes in caregivers' verbal input can be observed over children's preschool years (Goodsitt, Raitan, & Perlmutter, 1988). Initially, caregivers encourage and practise reading habits with their young children, such as turning only one page at a time and understanding that the words on the page relate to the pictures. During this phase, there is a focus on concrete word teaching. As children grow older, caregivers begin to delegate the responsibility for page-turning to the child, word teaching decreases, and there is an increase in utterances about the story content (Goodsitt, Raitan, & Perlmutter, 1988). With digital storybooks, such as tiptoi, new practices of reading must be learned. This is evidenced by the numerous behaviour-related comments caregivers use to guide their children on how to use or not use the medium (e.g., where to tap with the digital pen), structure the reading process to access the book's content, and explain the technology and its functions, including its possibilities and limitations (Wildt, 2024). Therefore, when selecting a new book format, adults should be aware that children might require initial exposure to this book format and practise their skills in accessing the book content in a new way.

Social Robots

In Section 2, "Underlying Principles of Interactivity and Scaffolding: Requiring 'Jointness' for Learning," we have argued that contingent social behaviour is foundational for children's learning. One technology that holds high promises is social robots. The term refers to complex artificial systems of an embodied

nature (van Straten, Peter, & Kühne, 2020; Kennedy, Baxter, Senft, & Belpaeme, 2016). These systems bear specific potential for language learning because they have a body and therefore can embed the learning process more deeply in social interaction (Mubin, Stevens, Shahid, Mahmud, & Dong, 2013) by systematically enriching an interaction through various communicative signals (e.g., gaze, gestures, or body posture). They thus provide a transition from physical to social interaction. Research has demonstrated that children not only socially conform to social robots (Vollmer, Read, Trippas, & Belpaeme, 2018) but also view them as trustworthy interaction partners from whom they can seek information (Breazeal, Harris, DeeSteno, Kory-Westlund, Dickens, & Jeong, 2016; Oranç & Küntay, 2020).

Over the past years, positive evidence on using social robots to support children's language learning has accumulated, demonstrating children's learning progress in various areas of language development, e.g., in terms of expanding their vocabulary (Vogt, Berghe, Haas, Hoffman, Kanero, Mamus, Montanier, Oranc, Oudgenoeg-Paz, Garcia, Papadopoulos, Schodde, Verhagen, Wallbridgell, Willemsen, De Wit, Belpaeme, Goksun, Kopp, Krahmer, … Pandey, 2019; Alemi and Basirib, 2016), improving their narrative or grammatical skills (Conti, Cirasa, Di Nuovo, & Di Nuovo, 2019; Kory-Westlund, Jeong, Park, Ronfard, Adhikari, Harris, DeSteno, & Breazeal, 2017; Kennedy, Baxter, Senft, & Belpaeme, 2016), and enhancing their reading skills (Gordon, Breazeal, and Engel, 2015). It is important to note, however, that in the field of child-robot interaction, some studies evaluate learning outcomes based on different interactional behaviours of the robot (e.g., de Wit, Brandse, Krahmer, & Vogt, 2020), while others focus on the overall effectiveness of social robots compared to other technologies (e.g., Westlund, Dickens, Jeong, Harris, DeSteno, & Breazeal, 2015). In addition, there is a great deal of variability in the assessment and measurement of learning outcomes, and previous studies have mostly focused on testing children's receptive comprehension in specific contexts. This means, for example, that the evaluation of learning gains in child-robot interaction often focuses merely on whether a child can identify a referent from a selection of objects by pointing to it on a screen. Therefore, there is still a lack of studies investigating how children can receptively and productively retrieve the knowledge learned through interaction with a social robot across different contexts and over extended periods (Kanero, Geçkin, Oranç, Mamus, Küntay, & Göksun, 2018; but see Tolksdorf, Crawshaw, & Rohlfing, 2021).

Beyond methodological aspects, technical challenges also remain to be addressed. More specifically, current autonomous robot systems are not capable enough of responding to the variance in children's (verbal and nonverbal)

behaviour and building on their contributions appropriately, which is why the interaction often breaks down. The reason for this less contingent interaction lies mainly with the robot, as current systems are not able to adequately account for children's multimodal behaviour and the characteristics of children's developing turn-taking skills (Rohlfing, Ceurremans, & Horst, 2017; Tolksdorf & Mertens, 2020). This was evidenced by the fact that children frequently socially referred to their caregivers during their interactions with a robot, and the caregivers then mediated the interaction between the child and the robot (Tolksdorf, Crawshaw, & Rohlfing, 2021).

Although these findings highlight the need for further child-oriented progress in the technical recognition and processing of social environments (Belpaeme, Kennedy, Ramachandran, A., Scassellati, B., & Tanaka, 2018), robots used as social agents in interactions offer an additional unique characteristic that has been relatively unexplored. This characteristic is the capability of fulfilling different social and dialogical roles (Rohlfing, Altvater-Mackensen, Caruana, van den Berghe, Bruno, Tolksdorf, & Hanulíková, 2022), which bears great potential. Social robots can be employed in innovative learning scenarios where, in addition to traditional social roles such as tutor or peer, they can act as, for example, novices. One of the first studies investigating the potential of social robots as novices was conducted by Fumihide Tanaka and Shizuko Matsuzoe (2012). In their study, the robot was not more competent but in need of learning. This approach aimed to reverse the typical roles, making it children's task to teach the robot. This learning concept is known as "learning by teaching" (p. 79). In the reported study, 3- to 6-year-old children played a verb game. First, an adult demonstrated the procedure: he took a card depicting an action and presented it to the robot. The robot initially responded by performing an incorrect, pre-programmed action. In the next step, the robot was guided through the action, followed by programming the robot's body so that the action could then be played back. The children learned some of the verbs with the robot and others without it. The results of the study indicate that children were better able to recall the verbs learned with the robot both immediately after the game and three to five weeks later. However, the design of this study does not allow for determining whether the children experienced the learning benefit from the robot or the demonstration. Nevertheless, the idea of allowing children to take on a reversed role is promising and suggests that role reversal can promote spontaneous learning.

This aspect of interactivity, namely, the flexible handling of a dialogical role, is innovative. Current research suggests evaluating further innovative roles, such as nudging or prompting children's communicative behaviour

(Rohlfing, Altvater-Mackensen, Caruana, Van den Berghe, Bruno, Tolksdorf, & Hanulíková, 2022). Such approaches, which allow a child to be involved in interactions in a specific but flexible ways depending on the activity or content to be learned, may offer a unique opportunity to complement the future educational landscape (Rohlfing, Altvater-Mackensen, Caruana, van den Berghe, Bruno, Tolksdorf, & Hanulíková, 2022).

Overall, while there is support for the potential of social robots in educational settings for language learning, and indeed, important stakeholder groups such as teachers (Serholt, Barendregt, Vasalou, Alves-Oliveira, Jones, Petisca, & Paiva, 2017) or parents (Tolksdorf & Rohlfing, 2020) are indeed open to the use of this technology, there remain important questions that have not yet been addressed by research. In particular, while social robots could provide support for children's learning in different domains, research is still in the early stages of understanding how they could be used long-term in institutional educational contexts. This would allow both teachers/educators and children to benefit from such technologies and enrich the pedagogical work in these settings (Tolksdorf, Siebert, Zorn, Horwath, & Rohlfing, 2021; Ahmad, Mubin & Orlando, 2016).

Individual Differences in Development Taken into Consideration by Media and Technologies

In the following, we will elaborate on important limitations of media and technology use, highlighting the imperative of considering children's individual differences in development, skills, and capabilities.

Children Benefiting from Early Literacy Support

Past research has consistently highlighted certain groups of children as needing more literacy support than others. This is the case for boys rather than girls, children of parents with low rather than high socioeconomic status (SES) and with migration background, who have been shown to score lower in reading skills across nearly all countries (Mullis, Martin, Gonzalez, Kennedy, 2003). Astrid Wirth, Simone C. Ehmig, Lukas Heymann, and Frank Niklas (2020) suggest that digital media has the potential to enhance the quality of the Home Language Environment (HLE) for the three aforementioned groups. With regard to the gender gap (Brozo, Sulkunen, Shiel, Garbe, Pandian, & Valtin, 2014), boys' interest in digital media can support and sustain their interest in reading. Thus, storybook apps and e-books can be an initial step to foster

boys' reading motivation. Moreover, some storybook apps or e-books feature narrator voices available in multiple languages, which is a notable benefit for parents and educators engaging with multilingual children (Bus, Broekhof, & Vaessen, 2023; see also Norwegian Reading Center, 2022). In addition, preschool-age children from middle- and low-SES families seem to benefit in vocabulary learning from the autonomous use of interactive apps, suggesting that high-quality mobile games show promise for reducing the gap in vocabulary development (Dore, Shirilla, Hopkins, Collins, Scott, Schatz, & Hirsh-Pasek, 2019; Golinkoff, Hoff, Rowe, Tamis-LeMonda, & Hirsh-Pasek, 2019).

Children's Individual Learning Pathways

The potential of technology also extends to groups of children who learn at different paces in their language development. Daisy J. H. Smeets, Marianne J. van Dijken, and Adriana G. Bus (2014) studied children aged five to six and a half years diagnosed with a developmental language disorder (DLD). The children learned new words from electronic books, unaccompanied by an adult. Interestingly, static pictures were more effective in supporting word learning than books with videos. In a second experiment, the authors showed that auditory distraction significantly interfered with the children's word learning, likely because children with DLD often have speech perception deficits in noisy environments. Therefore, careful consideration of the input is necessary to choose the right media and technology. This conclusion is also supported by studies on social robots, which have the potential to become adaptive technology capable of perceiving individual preferences and capabilities. For this technology, it has been shown that children with better vocabulary and phonological memory were more distracted by robots that used expressive gestures and learned more effectively when the robots remained gesture-free (van den Berghe, Oudgenoeg-Paz, Verhagen, Brouwer, de Haas, de Wit, Willemsen, Vogt, Krahmer, & Leseman, 2021). Not only particular capabilities, but also temperamental characteristics can influence how the interaction unfolds. Interestingly, these effects can differ between interactions with humans versus technology: Nils F. Tolksdorf, Franziska E. Viertel, and Katharina J. Rohlfing (2021) found that, unlike in human–human interactions (e.g., Hilton & Westermann, 2017), children's shyness did not affect their ability to recall new words learned from robots. This highlights the importance of considering individual characteristics in learning outcomes related to using social robots. In this vein, for social robots to be beneficial for children's individual learning, they need to recognise children's speech and nonverbal behaviours to provide adaptive responses.

Understudied Groups of Children

It should be critically noted here that the potential of technological support described above has mostly been demonstrated in older children (from four years onwards). One of the few studies concerned with younger children and an app designed specifically for word learning was conducted by Catherine Walter-Laager, Kathrin Brandenberg, Luzia Tinguely, Jürg Schwarz, Manfred R. Pfiffner, and Barbara Moschner (2017). The word learning app offers both description and search games. In the description game, objects are displayed, and when touched, a voice says the corresponding word. In the search game, words are heard for which the corresponding object is to be found by touching it. These games establish a direct and clear connection between the word and the referent. The study involved 98 German-speaking children aged between 23 and 31 months. divided into four groups: tablet with accompaniment, tablet without accompaniment, picture cards with accompaniment, and picture cards without accompaniment. Accompaniment refers to the presence of an adult who supported the learner through the following actions: demonstrating how the game works, repeating the expressions for the objects, and expanding the expressions into complete sentences. Children in the group who learned with a tablet and were accompanied by an adult showed the greatest increase in knowledge in this study. There was also a noticeable increase in learning in the unaccompanied group. The groups using picture cards were not able to expand their specific vocabulary. An advantage of children's already established vocabulary became visible in this study: children with large vocabulary scores learned best. The authors conclude that the interactivity in apps aimed at word learning can be a useful supplement to activities with children and an alternative to picturebooks. However, these apps should not be understood and used as "digital baby-sitter" (p. 1070).

Another limitation of the research presented above is that the influence of digital media on children's language development originates mainly from Western societies, with a focus on middle- to upper-class families (Ribner & McHarg, 2021). Therefore, not only children of younger ages but also those from diverse cultural backgrounds still represent an understudied population. This clearly limits our understanding of how digital media and technology, deeply embedded in the cultural contexts of children's everyday environment, influence language development. In this vein, research emphasises the importance of situating studies with new technologies within the broader cultural and social processes, including the institutional aspects of childhood, education, and family dynamics. Notably, the existing studies that take a cross-cultural perspective show that cultural differences primarily emerge not in the specific

activities children engage in with technology, but in how societal regulations and norms are influenced by societal regulations and norms that shape children's development and childhood (Süss, Suoninen, Garitaonandia, Juaristi, Koikkalainen, & Oleaga, 2013). This underscores the need for research on children of various ages and cultural backgrounds to enhance our understanding of the diverse influences digital media has on children's development (see also Rohlfing, Tolksdorf, Honda, Grimminger, & Sekine, 2024).

Conclusions

In our literature review, we highlighted the potential of diverse media and technologies to support children's language development in a variety of ways. Keeping this potential in mind, there are important challenges for researchers and developers in the field, and we identified some of them in our literature survey. While previous literature reviews lay out specific cognitive and affective outcomes observed in children interacting with different technologies, we add a critical and concise examination of how different technologies can enhance social interaction and the co-construction of knowledge through interactivity. Drawing from an interactionist view on language acquisition (Rohlfing, Wrede, Vollmer, & Oudeyer, 2016) and learning models suggesting that the involvement of the learner is crucial for knowledge construction (Chi, 2009), we underscore the importance of creating interactive environments, either facilitated by caregivers (e.g., co-viewing, dialogic reading) or by high-quality media engaging the child (e.g., interactive educational apps). However, engagement is a "multidimensional construct" (Clinton-Lisell, Strouse, & Langowski, 2024, p. 2; Fredricks, Blumenfeld, & Paris, 2004) encompassing behavioural, emotional, and cognitive dimensions, all of which are crucial for children's comprehension and learning (see Clinton-Lisell, Strouse, Langowski, 2024 for a review). In this regard, parents demonstrate higher engagement when using a familiar medium (Clinton-Lisell, Strouse, & Langowski, 2024; Howard & Roberts, 2002), which speaks to the importance of choosing parents' preferred mediums. Because of the known book-reading format and experience engagement with parents, the advantage of digital books (e.g., e-books or digital reading pens) is that children know how to use them and can use them independently. Although digital reading media can serve as supplementary tools for literacy development (Rothstein, 2017), further work is needed to improve the quality, ensuring that when interactivity is limited, the story itself should be highly engaging (see Norwegian Reading Center, 2022).

Critically, we have identified significant gaps in the current understanding of the potentials and challenges that technology presents for understudied groups, such as young children and those from diverse cultural backgrounds. Although the field of children's interaction with technology is dynamic and rapidly evolving, most research has focused on English-speaking individuals from Western countries and has not adequately addressed the needs of younger children or those from varied cultural backgrounds. The imperative is thus to include these often-overlooked groups in the design, development, evaluation, and implementation of child-oriented technologies and media. Additionally, more cross-cultural studies are needed to reveal significant differences in children's interactions with technologies, such as social robots across cultures. Demonstrating differences in engagement displays and enjoyment across cultures (Shahid, Krahmer, & Swerts, 2014; Rudovic, Lee, Mascarell-Maricic, Schuller, & Picard, 2017) underlines the potential of technology as a valuable means to explore and better understand cross-cultural communicative behaviours in children, suggesting that technologies like social robots can be systematically used to control interaction parameters across different cultural settings (Rohlfing, Tolksdorf, Honda, Grimminger, & Sekine, 2024).

Furthermore, we have acknowledged the potential of emerging technologies, such as social robots, for language learning in educational settings, but we also call for more research to expand our understanding of how children can deepen their knowledge through long-term, sustained interactions with social robots. To achieve the next step in child-orientated interaction, technology needs to dynamically react to children's individual ways of communication and adapt as the interaction unfolds. In addition, serious studies on how advanced technologies can be effectively integrated into educational settings, ensuring they align with pedagogical values and institutional norms (Tolksdorf, Siebert, Zorn, Horwath, & Rohlfing, 2021). Finally, we encourage interdisciplinary collaboration to further explore innovative ways for supporting children's language development and digital participation, aiming to forge new paths at the intersection of technology, education, and child development (Rohlfing, Altvater-Mackensen, Caruana, van den Berghe, Bruno, Tolksdorf, & Hanulíková, 2022).

Before drawing conclusions, it must be noted that our perspective is limited to studies on young children's language learning and how media and technology can support it. We did not consider how aesthetic or artistic development is supported.

In drawing conclusions, we offer some recommendations for caregivers regarding media usage in early childhood. Generally, children benefit most

from well-adjusted interaction with competent partners. In this vein, our literature review underscores the importance of active caregiver involvement, setting appropriate screen-time limits, and introducing the use of media as an interactive tool rather than passive engagement. Within this context, both European and American educational policy guidelines provide recommendations on the importance of careful selection and use of screen media for young children. However, age-specific recommendations differ between European and American guidelines. The German AWMF (Arbeitsgemeinschaft der wissenschaftlichen medizinischen Fachgesellschaften) [German Association of Scientific Medical Societies] advises keeping children under the age of three away from any passive or active use of screen media, which is supported by numerous campaigns (e.g., Screen Free Until 3, n.d.). For children aged three to six, gradual introduction to screen media is suggested, with usage not exceeding 30 minutes on individual days, accompanied by parents (e.g., co-viewing, see the "Television" subsection), and involving high-quality programs. In contrast, American guidelines are less strict regarding the age at which children can begin using screen media. The American Academy of Pediatrics (2016) recommends minimising or eliminating media exposure, other than video chatting, for children under 18 months. For children aged 18–24 months, the use of high-quality programs is recommended to be watched together. For children aged 2–5 years, screen use should be limited to one hour per day of high-quality programs. One limitation of both European and American guidelines is that they primarily address media with audiovisual content – essentially all devices with electronic screens or applications requiring an electronic screen. However, there are currently no specific recommendations for newly emerging technology, such as hybrid reading media that combine printed books with a digital pen (e.g., tiptoi), or for interactions with social robots.

Overall, we further extend what we presented in the "Digital Audio Pens" subsection by stating that when choosing a digital medium, it is recommended for educators and caregivers to introduce the child to the 'rules' of handling it, including its functions and possibilities of interaction with technology. During the initial usage period, a child's interest may focus more on the medium itself rather than on the content. Thus, adults play a crucial role in helping children become more comfortable with the digital medium and its features, thereby enabling children to shift their focus towards the content. Further, we highly recommend critically considering the risks and potentials of using rapidly developing technologies. Above, we provided some well-motivated dimensions along which these considerations can take place.

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