

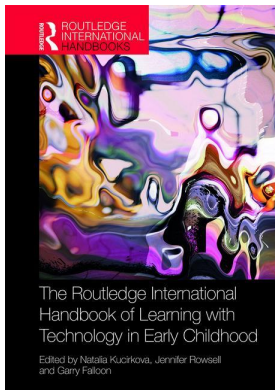
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17

TECHNOLOGIES, AFFORDANCES, CHILDREN AND EMBODIED READING

A case for interdisciplinarity

Anne Mangen, Trude Hoel and Thomas Moser

Introduction: technologies, affordances and embodiment

Digital technologies pervade our lives, and more and more of our reading is done on screens rather than on paper. Young children also engage in an increasing diversity of screen-based devices, and in several countries there is a noticeable political push toward implementing Information and Communication Technology (ICT) in early childhood education (e.g. Lynch & Redpath, 2014). This situation invites a number of intriguing research questions on topics related to children, technologies, literacies and reading. At the same time, it provides a timely occasion to reflect on the ways in which such research questions are currently pursued in the field.

In spite of a prominent place on the agenda of a number of researchers and teachers, as well as policy makers (e.g. Kamylyis et al., 2015), digital technologies in early childhood remains a contentious topic, with advocates of increased accessibility and use pitted against those urging for caution, and even abandonment, in the use of screen technologies with children. A conspicuous example of the latter, neuroscientist Manfred Spitzer (2013) contends that touch screens are particularly bad for children's cognitive development. Claiming that swiping your fingers across a screen is 'one of the dumbest things one can do with the hand' (2013, p. 96), Spitzer argues that the interaction with the allegedly intuitive and user-friendly interface of touch screen tablets is in fact undermining the vital learning potential embedded in children's haptic and tactile – or, in general, corporeal (bodily) – exploration of their surrounding world:

The development of a child's brain depends upon challenging interactions with the world around: with their senses and ideas, hearts and hands, children conquer the world, learn about objects and features, rules and exceptions. Not only is swiping hardly motorically challenging, it also does not make much use of the hand as a sense organ [...]. Furthermore, given that the motor phenomenon is always almost identical, just as the tactile sensory feedback, there cannot be any holistic experiences of various different things, which in the long run make up our understanding of the world around us.

(Spitzer, 2013, p. 96)

Embodied and multisensory exploration of three-dimensional objects is also crucial to children's capacity for imagery and fantasy (e.g. Burnett & Daniels, 2015), and pretend-play with blocks, dolls and construction toys are major contributions in this respect (e.g. Singer & Singer, 2005). Building blocks and construction toys are tangible objects with distinct textures and other surface features, providing substantially different haptic and tactile feedback than intangible screen representations. Hence, we may ask what difference it makes that children play with virtual building blocks appearing on a screen rather than the wooden, three-dimensional ones existing in real-life. More specifically, we need to ask whether and to what extent the intangibility of screen representations affects children's cognitive development (and reading with it), and what the implications of this may be in a short and a long-term perspective.

In this article, we will address these issues by looking at shared reading with print picture books and picture book apps in Early Childhood Education and Care (ECEC) institutions. Books and tablets are material objects with medium-specific interfaces and ergonomic affordances inviting certain kinds of interaction, for instance, with respect to pointing and navigation. Because books have been the dominant reading medium for a very long time, we have become so used to handling them that the features of their user interface have become largely transparent. However, when books, and paper, are being replaced by digital media – laptops, tablets, smartphones and screens – their distinct user interface is revealed.

Reading – whether shared or individual, at home or in kindergarten – is an example of embodied, multisensory human-technology interaction (Mangen & van der Weel, 2016), involving in particular our fingers and hands when manually handling a device and navigating a text. Nevertheless, the ergonomics – and, more specifically, haptics – of reading has only recently begun to attract scholarly attention, in research on reading and literacy overall (Brinkmann & Tanggaard, 2010; Mackey, 2018; Mangen, 2008, 2016; Mc Laughlin, 2016), as well as in the field of early childhood learning (Crescenzi et al., 2014; Kokkola, 2018; Mackey, 2018; Merchant, 2015; Yuill & Martin, 2016).

A main implication of the transition from paper to screens is the need for theoretical perspectives that can accommodate sensorimotor and ergonomic aspects as well as the more commonly addressed visual, cognitive and discourse – or text-/meaning-related ones, to understand how the change of substrate may affect reading – whether in dyads (e.g. mother-child) or in groups (e.g., in ECEC settings). In the following, we suggest that insights deriving from the interdisciplinary paradigm of *embodied cognition* are well suited for such a task. The increasing influence of digital technologies in kindergartens is thus a timely occasion to bridge a persisting gap between predominantly qualitative, sociocultural and constructivist approaches on the one hand, and theoretical perspectives, methods and measures more common in experimental disciplines (e.g. psychology, neuroscience) on the other. Studying shared reading through the lens of embodied cognition (e.g. Mangen, 2016; Mangen & Schillhab, 2012; McLaughlin, 2016) may hence serve to broaden and deepen our understanding of the role of technological interfaces and, in particular, haptic and tactile affordances, for children's cognitive development and, in so doing, pave the way for more interdisciplinary research in the field.

The role of narratives and storytelling in children's language development

Children's multisensory exploration of material, tangible objects in their physical surroundings is fundamental to their cognitive development. Another cognitively stimulating activity nurturing in particular their fantasy and imagination is that of shared storybook reading. Young children are traditionally introduced to narratives and picture books in a context of mediation, in which

dialogues and language are crucial. This context plays an important role in children's language development. Comfortably seated in the lap of a loved and trusted adult, or in the company of peers as in shared reading in groups (Tønnessen & Hoel, accepted), children are introduced to imaginative worlds conveyed through the language of the text and images, mediated by the adult through his or her act of reading. The safe and cozy setting, as well as the ways in which the adult can adapt and tailor the reading to resonate optimally with the children, contribute to making storybook reading an ideal space for language stimulation and cognitive development (Barzillai et al., in press; Vander Woude et al., 2009). Not surprisingly, storybook reading has been shown to support language and literacy skills (Lonigan & Whitehurst, 1998; Mol & Bus, 2011; Mol et al., 2008; Sénéchal, 1997; Wasik & Bond, 2001), and to boost reading interest and enjoyment overall (Baker et al., 2001). Hence, shared storybook reading is pivotal in kindergarten teachers' pedagogical repertoire.

Children's language skills are crucial in play and in establishing social relations with peers in everyday life (Brekke Stangeland, 2017), as well as for further learning, reading and writing in school (Aukrust & Rydland, 2011; Hagtvet et al., 2011). Children develop and elaborate their language skills by using it in social and meaningful situations. Participating in dialogues related to literary texts may therefore contribute positively to their language development (Slettner & Gjems, 2016).

When engaging in rich dialogues during picture book reading, children are involved in *extended discourses* (Dickinson & Tabors, 2001), actively building on their own experiences and skills, and constructing new knowledge (Solstad, 2016). When children engage creatively in dialogues in this way, their language is more decentered and decontextualized than their everyday language. Adults can invite children to participate in such cognitively developing dialogues by means of systematic and research-based methods for shared reading, e.g., *dialogue-based reading* (Burger, 2015). In dialogue-based reading, the adult is in charge of initiating and maintaining a dialogue with the primary objective to engage children in using decentered language. Invitations to dialogue can take different forms, such as questions detaching the conversation from the here-and-now (Smith & Dickinson, 1994).

Participation in reading activities thus contributes to children's language learning. In addition, children learn about books as cultural objects, and they are introduced to the ways in which a particular culture engages with books and texts (Mjør, 2009). The print picture book invites to extended discourses involving both children and adults, by means of multimodality, in which text and images interact narratively, semiotically and aesthetically. Words – written or spoken – and pictures are closely linked to the book as a medium, as a physical object with book cover, pages, spreads and paratext (Genette & Maclean, 1991). Such medium-specific affordances provide a concrete framework for the communication and dramaturgy of the narrative.

The adult reader mediates between the text and the child reader, monitoring how the text communicates with the children. Marilyn Cochran-Smith (1984) characterizes the adult reader as a 'mediator-monitor' (p. 259). If the relationship between text and child reader is challenging, the mediator can compensate and bridge between the two. Thus, a mediator does not stage an automatic dissemination of the text, especially when reading for younger children; 'parents adapt their reading style to their child's competence' (Bus, 2001, p. 186).

The ways in which adults as well as children use their hands during reading are particularly noteworthy. A print book is typically held, positioned and manipulated in particular ways, and page turning is tactile in a different sense than page turning on a screen. Children and adults often touch the page, for example by pointing to emphasize action, identify characters and explore details in the illustrations. The pointing finger may also serve to mark the reading direction. When reading aloud, two-page spreads and page turning can act as impulses to the pace

of the reading, and the act of page turning can itself harbor a dramatic potential. In fact, argues Mackey, 'this element of *connecting with hands* may be one of the specific pleasures of reading graphic texts together and one reason why picture books are so often cited as creating bonds between the adult and child who read them together' (Mackey, 2007, p. 119). Moreover, when children participate in dialogue-based reading, they also get first-hand experience of the use of texts, and physical books, in their culture. Children learn what reading is and what a reader does, and they are introduced to cultural conventions for meaning making.

When dialogue-based reading makes the transition from the substrate of paper to a variety of screens, a number of intriguing research questions arise: does it matter for children's engagement in the story that page turning is done by tapping or swiping across a screen rather than by flicking through paper? How may the differences between pointing on pictures in a print picture book, and on animations in a picture book app, affect the reading? How and to what extent do the ergonomic – haptic – engagement afforded by the material affordances of touch screen displays interact with the dialogue during reading, or with children's attention or engagement in the story?

Storybook reading on paper and screens: sensorimotor contingencies

Digitization warrants us to consider new aspects of storybook reading, such as the role of the medium. For a very long time, reading has been the exclusive domain of print. However, the emergence of tablet technologies has prompted the production of picture book apps particularly targeted at young readers. Such apps come in a wide variety, ranging from digital and interactive renditions of classics such as *Moomin* and *Pippi Longstocking*, to 'digital-only' productions that may seem more like games than stories. The degree and type of narrativity, as well as the interplay between text, pictures, animations and sounds, vary considerably. Some digital storybook apps resemble games more than stories in that there is little in the way of a coherent and progressing narrative, whereas others seem like animated versions of their print predecessor (e.g., Kari Stai's (2008) books about Yesper and Noper, several of which are available as apps). Common to them all is that the *intangibility* of the digital text (including the pictures, animations and sound) affects the readers' haptic engagement with the medium (Mangen, 2010). This intangibility has implications for the ways in which a reader is inclined to handle the text (and the medium). The very possibility that something on screen may change as a result of our motor input (clicking, tapping or swiping) is a defining feature of a digital text. This may lead to an 'urge to click' (Mangen, 2008) which has shown to be potentially distracting to the comprehension of, or engagement in, the story during reading (Parish-Morris et al., 2013). However, depending on the nature of the interactive affordances ('hot spots'), such a feature also has the potential to enhance children's engagement (see Bus et al., 2015 for a review).

In a time of rapid technological developments and increasing diversity, there is an urgent need to establish empirically what factors in the context-medium-text-reader nexus contribute positively to children's socioemotional engagement and cognitive development, and which may undermine such development. Vital to such an endeavor is the task of assessing how the material and ergonomic affordances of the medium interact with the cognitive and emotional processes involved in the ongoing narrative engagement during (shared) reading. For this purpose, we suggest the need for a more thorough understanding of the *sensorimotor contingencies* of paper-based and screen-based devices. Sensorimotor contingencies (Noë, 2004; O'Regan & Noë, 2001) refer to practical and embodied knowledge of rules and regularities relating our sensory input to movement, changes and actions:

how things look, smell, sound, or feel (etc.) depends, in complicated but systematic ways, on one's movement. The sensory modalities differ in the distinctive forms that this dependence takes. [. . .] Sight has its own characteristic forms of sensorimotor dependence. How things look varies in systematic ways as one moves one's head, eyes, or body relative to the environment. [. . .] The senses are modes of awareness of one and the same environment as mediated by different patterns of sensorimotor contingency.

(Noë, 2004, p. 109)

Our practical knowledge of the laws governing these contingencies derives from our multi-sensory exploration of the physical environment. Children learn about the nature, features and behavior of things in the lifeworld through audiovisual, haptic and tactile exploration of objects with different weight, texture, shapes, sizes, smell and taste. Importantly, how things *look* is only one manifestation of the totality of features defining any one object. The print version and the app version of Stian Hole's award-winning title *Garmann's Summer* (Hole, 2008), for instance, may *look* identical, page-by-page, but they differ in sensorimotor contingencies. When reading the story in print, the text and pictures are fixed, and we can discern visually, as well as sense kinesthetically, our page-by-page progress through the text. In contrast, when reading the app, we may be able to see (e.g. using page numbers) but we cannot kinesthetically sense our page-by-page progress through the text. Empirical research on adults' reading of narratives has found that such lack of tactile feedback may negatively affect the reader's overview of text length, of reading progress and of location of events in the text (Mangen & Kuiken, 2014; Mangen et al., submitted). Whether and to what extent such differences in sensorimotor contingencies may also affect children's socioemotional and cognitive engagement are important empirical questions in urgent need of attention in a time when narratives and storytelling become increasingly screen-based rather than paper-based.

Multisensory, embodied reading with books and apps

Reading aloud is a multisensory experience – whether the story is read from a print picture book or from a picture book app on a touch screen. In the print picture book, texts and images are visual, but the voice of the adult reader contributes substantially to the reading experience. In addition, the adult reader can use sound effects as when, e.g., knocking on the table to imitate a door-knock in the story, or blowing a fanfare when the knight enters the stadium. Sound is also a powerful means to communicate emotions (Hoel, 2013) – for instance, to invite sympathy and empathy, such as when the adult uses a scared voice when she reads about little Emma who is afraid of the dark. The concrete setting of shared picture book reading is also characterized by a physical and emotional closeness that allows for direct bodily interaction, as when the adult tickles the children when reading about Lars who is ticklish. Such simulations of emotions and actions are likely to enhance children's understanding, through the children literally seeing, hearing and feeling what is happening in the story.

Similar to reading a story in a book, reading a story on a touch screen tablet is a multisensory and embodied experience. Differently from print, the digital medium enables seamless combinations of static and dynamic modalities and ways in which the reader can engage concretely with the content by means of different options for interactivity. In addition, the sensorimotor contingencies of the tablet imply that the haptic engagement with the text and the device have different outcomes than when reading a print book (Mangen, 2008; Merchant, 2015). Taken

together, such features contribute to making the reading experiences on a touch screen quite different from that of reading on paper in a book, and important research questions pertain to the effects of such medium-specific affordances on children's understanding and engagement.

Bus and colleagues (2015) conducted a meta-study of dyadic reading of digital narratives that include oral text and interactive elements like animations, sound effects and games. They find both positive and negative effects on children's emergent literacy development, depending on whether the interactive elements are related to the narrative. These results match those of another meta-study of reading dyads (Takacs et al., 2015) focusing on the impact of technology-assisted stories, compared to listening to narratives in more traditional reading situations. The study concludes that interactive features such as animations, music and sound effects contribute positively to children's understanding of the story as long as they are directly linked to the story, whereas 'hot spots', games and dictionaries not directly linked to the story, distract children's understanding. This was especially found to be the case for children growing up in non-reading environments (Takacs et al., 2015).

The physical closeness during reading with books and tablets has also been researched. In a study, Yuill and Martin (2016) compared the reading of a picture book with one read on an iPad, assessing what they call 'interaction warmth' and the posture of the children – sitting position or body position – while reading on the two devices (the mother reading for the child and the child reading for the mother). Finding that interaction warmth was lower for tablet reading than for book reading, the authors conclude that the physical differences between the book and the iPad 'can be expected to influence the embodied experience of shared reading' (2016, p. 11). The ergonomic affordances and sensorimotor contingencies affect the proximity as well as the nature of the interaction, making the two reading situations best described as 'curling up with paper [and] shoulder-surfing with screen' (2016, p. 8). As noted also by Yuill and Martin (2016, p. 11), the role of such differences is readily recognized in the increasingly influential research paradigm of embodied cognition.

Embodied cognition as an interdisciplinary frame for media-specific effects on shared reading

The acknowledgement of the role of the body in early childhood development and learning is not *per se* new: it was explicitly referenced in e.g. Piaget's (1936) epochal approach to developmental psychology, as well as in Merleau-Ponty's (1962) phenomenology. However, the emergence of a more coherent research paradigm known as embodied cognition has served to solidify an understanding of the importance of the physical, sensing, acting and moving body that is not primarily understood from cultural, social or semiotic perspectives alone. Beyond these, it is also informed by empirically derived knowledge from psychology and neuroscience on the associations between motor action, perception and cognitive and emotional processes at multiple levels.

In the educational sciences, the body has experienced a kind of renaissance in the last decades (Bengtsson, 2013; Evans & Davies, 2011; O'Loughlin, 1998) with a particular interest in embodied cognition and learning in recent years (Ionesco & Vasc, 2014; Leitan & Chaffey, 2014). Influences from a wide range of disciplines/schools of thought such as phenomenology (Gallagher, 2014; Stapleton & Froese, 2016) and neuroscience (Kiefer & Trumpp, 2012; Matheson & Barsalou, 2017) have contributed to developing the concept of embodied cognition to an influential theory in the field of education (Ionescu & Vasc, 2014; Kontra et al., 2012; McLaughlin, 2017; Yann & Martin, 2015).

According to Ionesco and Vasc (2014, p. 14), there are two main features characterizing embodied cognition: (i) cognition is not abstract and amodal but multimodal and grounded in

sensory modalities of the brain and in human action; and (ii) cognition is not just about thinking but also about perceiving and acting, therefore non-cognitive processes, such as emotions, have to be included. In line with this understanding and referring to Barsalou (2010), Antle (2013) states that '[e]mbodied cognition is a perspective based on the notion that psychological processes are dependent on and shaped by aspects of the body including body morphology (form), sensory-motor systems, and interactions with the surrounding world' (2013, p. 31). Humans are understood not as 'disembodied symbol processors' but as active agents when it comes to cognitive processes.

To provide a deeper understanding of the concept of embodiment, Núñez (1999, p. 55) suggests distinguishing between three levels: trivial, material and full embodiment. *Trivial* embodiment addresses the bodily basis for information gathering and processing, implying that cognition and other psychological processes are linked to biological structures (such as the nervous system) and processes (sensation, perception). One important consequence of trivial embodiment is the necessity to understand how the nervous system works, in order to really understand cognitive and other mental processes.

The second level of embodiment, *material* embodiment, goes beyond the bodily basis of cognitive processes to develop specific paradigms and methodologies. Cognition is considered to be a decentralized phenomenon, not solely linked to the central nervous system but also involving other biological systems. Material embodiment refers specifically to movement actions performed in specific environments – e.g. gross motor actions and visual scanning, called 'low-level cognitive tasks'. Such an understanding of embodiment does not exclude the possibility that there are cognitive processes that are largely independent of the body (i.e., disembodied).

The third level, *full* embodiment, comprises both trivial and material embodiment. In addition, it encompasses all cognitive processes up to the most abstract forms of thinking (e.g., mathematical concepts). In a full-fledged thinking, bodily processes bring forth all forms of knowledge and understanding, including scientific forms of understanding. As an example, Lakoff and Núñez (2000) demonstrate that one can understand mathematics as fundamentally bodily anchored. However, such an understanding of a total or radical embodiment, as Núñez (1999) himself notes, is still controversial. Nevertheless, Núñez's tripartite structure may help explicate the potential of embodied cognition in the field of early childhood learning.

We propose that an embodiment perspective has the potential to help create a more in-depth and interdisciplinary understanding of what matters to the quality of early reading processes. Such a perspective could provide analytical perspectives for a complex analysis of medium-specific effects in shared reading with young children, both in dyadic and group settings.

The need for (more) interdisciplinarity

'Literacy practices', says Kathy Mills (2015), 'cannot be performed without the body and mind, or without interaction with the tangible materials and skills that are part of a social field, contextualized, and enacted in particular places' (p. 144). However, despite an increasing acceptance of the importance of an embodied perspective when it comes to the use of digital technologies in early learning processes (Antle, 2013; Mangen & Balsvik, 2016), it is still somewhat unclear how such a perspective may be applied and what methodological approaches are required. Embodied cognition is a complex process involving a wide range of motor, perception, cognitive, social and emotional processes – many of which are not immediately available for direct observation. This, obviously, has methodological implications and hence invites a reconsideration of theoretical frameworks, paradigms and methodologies in the field.

Aiming to capture embodied aspects of children's interaction with technologies, researchers often apply perspectives from social semiotics, particularly multimodality theory. For

instance, Price and Jewitt (2013a, 2013b) emphasize the ways in which recent interfaces promote more embodied forms of interaction and invite a wide range of bodily movement, from whole body interaction with mobile and sensor technologies to hands-on manipulation with multi-touch and tangible interfaces. Calling for a re-examination of the methodological approaches in the field, they highlight the particular usefulness of a multimodal theoretical approach in that it supports a fine grained analysis of artifacts and interactions in which meaning is realized in the iterative connection between the meaning potential of a material semiotic artifact, the meaning potential of the social and cultural environment, and the resources, intentions and knowledge that people bring to that encounter (Price & Jewitt 2013a, p. 2907).

Often applied within a sociocultural paradigm, social semiotics and multimodality combine to provide a valuable tool for analyzing video data, since they accommodate the multimodality inherent in the representation of some content (e.g., text, animations, sound) as well as the multimodal and embodied forms of communication and interaction (e.g., posture, gaze, gesture, manipulation of objects) (Price & Jewitt, 2013b).

In pedagogically oriented research on learning and literacy in early childhood, sociocultural perspectives have been dominant for some time, and this research has contributed substantially to our understanding of the role of media and interfaces in children's learning. At the same time, the descriptive ethnographic bent of the sociocultural approach has led to a situation in which the effects of changing sensorimotor contingencies of technologies on cognitive and emotional processing have remained inadequately understood (Mangen & van der Weel, 2016). Moreover, by defining literacy and reading as socially constructed practices, research building on a sociocultural approach privileges social, cultural, ideological, political or other context-oriented aspects of literacy and reading, hence downplaying individual – sensorimotor, cognitive and emotional ones. As a consequence, research in the field seems somewhat skewed and there is an imbalance between qualitatively oriented research on one hand, and studies applying quantitative methods, on the other (Kucirkova, 2019).

The interplay between the sensorimotor contingencies of different media (books, tablets, computers) and substrates (paper, different kinds of screen displays), motor behavior, attention, perception, cognitive and emotional processes and sensory integration is too multifaceted to be captured by one theoretical framework and one methodology alone. Inspired by a recent epistemological discussion in the field of empirical research on literary reading (Dixon & Bortolussi, 2016; Jacobs, 2016a, 2016b; Kuiken, 2016), we propose that research in the field of technologies in early childhood would benefit from greater theoretical and methodological diversity. As also noted by Kucirkova (2019), more diversity is needed in order to better address and account for the multiple outcomes in studies of children's engagement with print and digital narratives, that cross personal/social and cognitive/emotional axes.

One way in which to pursue such a goal methodologically, we claim, is by an integration and combination of online and offline, direct and indirect, methods, as suggested by Dixon and Bortolussi (2016). Interacting with content mediated by and displayed on a variety of substrates comprises a range of cognitive, emotional, sensory and social processes and mechanisms. Some of these processes are verbal and/or directly observable and measurable, but many are preverbal or subconscious, and hence cannot be captured by video or in verbal data. This implies a need to supplement the tools and methods typically employed in socioculturally oriented research. Visualizing such a complementary approach in the field of empirical literary study, Dixon and Bortolussi (2016) present a matrix of four measurement classes: direct and indirect measures, and online and offline measures. Direct and indirect refer to the inferential relationship toward the dependent variable, whereas online and offline refer to the temporal relationship between

Table 17.1 Matrix of four measurement classes (Dixon & Bortolussi, 2016): direct and indirect measures, and online and offline measures

<i>Inferential relationship</i>	<i>Temporal relationship</i>	
	<i>Online</i>	<i>Offline</i>
Indirect	Examples: Eye movements, pupil dilation, EEG, fMRI, psychophysiological measures	Recall, judgment response time
Direct	Concurrent verbal protocols, probe responses, text annotation	Questionnaires assessing reactions and experience, interviews

the phenomenon to be studied (e.g., reading) and the measure (online, during the act; or offline, after the act – i.e., measuring the results of a process).

Obviously, some of the tools and measures in Table 17.1 are less appropriate in research with young children (e.g. pupil dilation, eye movements, text annotation). More importantly in the present context, such an approach makes explicit the necessity to collaborate in interdisciplinary teams contributing different theoretical perspectives and methodological expertise. Systematically reviewing the most recent research on digital reading in early childhood, Kucirkova (2018) finds that there is little exchange between scholars applying primarily qualitative methods on the one hand, and research based primarily on quantitative data, on the other. In studies applying a semiotic or multimodal literacies perspective (Harde & Kokkola, 2018; Jewitt, 2006; Jewitt et al., 2009; Kress, 2010; Rowsell & Pahl, 2015), relevant research in biology, psychology and neuroscience is marginally referenced, if at all. Analogously, experimental research in psychology and neuroscience rarely consider aspects more common in socioculturally oriented research. Such a theoretical–methodological ‘schism’ implies that important aspects of the interaction between the medium, the narrative, the children and the reading adult remain inadequately addressed. In particular, this pertains to pre- or non-verbal processes and to the complex interplay between fine-motor actions and emotional and cognitive mechanisms that may be important beyond that of contributing to explicit meaning making.

One way for future research to address this ‘schism’ could be to analyze children’s engagement with technologies in an embodied perspective, by including various aspects of motor behavior and posture as observable variables in experimental and other research designs. The following aspects might be of relevance in studying activities related to digital devices in a variety of ECEC settings:

Posture

- Position in space
- Body orientation (open-closed; introvert-extrovert)
- ‘Body control’ (rest-unrest)
- Position in relation to the device
- Position in relation to peers and adults (teacher)
- Mimicry, facial expression

Gesture, pointing

- Frequency and intensity of gestures
- Directedness (intentionality) of pointing

Body movement (gross motor)

- Movement intention, purpose
- Direction (horizontal and vertical movement)
- Frequency, intensity and duration

Fine-motor activity

- Grasping
- Eye-hand-coordination

These aspects of motor behavior and posture can mainly be observed by others, with and without technologically supported measurements, and described in various ways. In empirical studies, the indicators for motor behavior and posture should be chosen based on theoretical reflections and the understanding of the concept of embodiment, as well as the particular research questions. These indicators may be investigated alone or in combination with other variables as captured in, e.g., verbal responses.

To conclude: the role of the body, and of motor actions and sensorimotor experience in children's cognitive processing, go far beyond the body being another sign system or semiotic modality. Rather than – or in addition to – bending and stretching extant sociocultural paradigms to match an increasing technological complexity, we propose to pursue collaborative, interdisciplinary research in which relevant insights from embodied cognition, sensorimotor contingency theory and medium affordances are combined with relevant qualitative approaches (e.g., theories of narrativity, multimodality, and semiotics) to shed a more comprehensive and nuanced light on the issue. This is a challenging task, but time is ripe for more collaboration across the humanities–social sciences gap.

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