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Natalia Kucirkova & Ida Bruheim Jensen

To cite this article: Natalia Kucirkova & Ida Bruheim Jensen (19 Oct 2023): Children's early reading through the sense of smell: a typology of olfactory engagement, Early Child Development and Care, DOI: [10.1080/03004430.2023.2269319](https://doi.org/10.1080/03004430.2023.2269319)

To link to this article: <https://doi.org/10.1080/03004430.2023.2269319>



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Published online: 19 Oct 2023.



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Children's early reading through the sense of smell: a typology of olfactory engagement

Natalia Kucirkova^a and Ida Bruheim Jensen^b

^aNorwegian Centre for Learning Environment and Behavioural Research, University of Stavanger, Stavanger, Norway; ^bDepartment of Social Studies, University of Stavanger, Stavanger, Norway

ABSTRACT

We investigated adult-child shared book reading of olfactory books that stimulate the sense of smell through scratch-and-sniff surfaces. We observed ten adult-child dyads reading olfactory books at home and documented the characteristics and quality markers of their olfactory engagement. Drawing on the principles of learning sciences and socio-cultural learning theories, we propose a Typology of Olfactory Engagement that brings to the fore the potential of actively engaging the sense of smell during shared book reading. We outline how the Typology of Olfactory Engagement can serve as a basis for future studies exploring adult-child interaction in home learning environments.

ARTICLE HISTORY

Received 14 March 2023
Accepted 2 October 2023

KEYWORDS

Book reading; parent-child interaction; smell; olfaction

The rich history of early learning studies has illuminated the precursors and mechanisms for social, behavioural and cognitive types of learning but less so for sensory learning that engages *all* six human senses, including olfaction, gustation and proprioception. In this study we examined olfactory learning, which is learning mediated by the human sense of smell. Given that there is no framework to analyse children's learning through and with smell, we needed to create a typology of olfactory learning for our empirical study. We adopted existing Shared Book Reading (SBR) frameworks and developed a new analytical framework focused on adult-child physical olfactory engagement. We carried out a detailed analysis of adult-child shared book reading of olfactory books to explore the ways in which the principles of social, contingent and multisensory learning get mobilized during adult-child SBR. We suggest that our focused analytical approach to olfactory engagement brings to fore new dimensions of learning in the SBR context, which we capture in a Typology of Olfactory Engagement.

Senses and learning

The hierarchy of senses in the education history has led to logocentric learning sciences that privilege verbal and written language over other sensorial types of communication (Howes, 2021). Historically, the visual and auditory senses have been given a prominent role in learning and clinical studies, while the 'lower senses' of touch, olfaction and gustation have been underexplored. Nevertheless, following the ubiquitous presence and multisensory affordances of multimedia devices in everyday learning environments, researchers have been increasingly interested in the role of lower senses (Spence, Obrist, Velasco, & Ranasinghe, 2017). Recently, accentuated by the loss of

CONTACT Natalia Kucirkova  natalia.kucirkova@uis.no  Norwegian Centre for Learning Environment and Behavioural Research, University of Stavanger, Stavanger NO-4036, Norway

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sense of smell after the COVID-19 pandemic (Hopkins et al., 2021), the role of the sense of smell for everyday functioning and wellbeing has become a topic of widespread interest (Herz & Bajec, 2022). We build on this interest with a focus on the role of olfaction in children's learning.

Olfaction and learning

Drawing on cross-cultural studies and the nascent olfactory cognitive science, Herz (2000) and Agapakis and Tolaas (2012) argue that the sense of smell carries an untapped learning potential. Studies focused on olfactory learning with pre-school-aged children are scarce, but they indicate significant variability in how young children perceive and verbalize odours (Bensafi, Rinck, Schaal, & Rouby, 2007). In addition, odour fulfils different roles depending on the child's needs. For example, familiar odours of mothers and siblings, act as 'social buffering' for pre-school children and help with soothing stress and anxiety (Schaal, Saxton, Loos, Soussignan, & Durand, 2020). The ability to memorize and verbalize odours develops as children's cognitive abilities mature, with ten-year-olds reaching the same odour performance scores as adults (Lehrner & Walla, 2002).

Experimental evidence shows that olfaction is essential for human navigation in space (Dahmani et al., 2018), presumably because of the navigational demands in animal species and humans and the close association between imagery, memory and olfaction (Croijmans, Speed, Arshamian, & Majid, 2020). Some futurologists (e.g. Sissel Tolaas) predict that future schools will teach children to use their noses to navigate in the world. Reflecting on the learning potential of olfaction, Professor Asifa Majid (2021), one of the leading experts in olfactory research, proposed that 'Rather than focusing on constrained experimental tasks, olfactory researchers could benefit from considering human olfaction in all of its contexts to study how people across the globe use, manipulate, and talk about odours in their day-to-day contexts' (p. 120). One such day-to-day context is the activity of book reading.

Olfaction and book reading

Given the strong connection between olfaction, emotion, and memory (Willander & Larsson, 2007), olfaction might be particularly helpful in parent-child reading interactions, which are characterized by the engagement of cognitive and affective resources (Kassow, 2006). Thus far, olfaction has been little explored in reading. The need to draw increased attention to the sensorium in reading studies has been advocated by multimodal and posthuman scholars, particularly in reference to haptic engagement (Crescenzi, Jewitt, & Price, 2014); movement (e.g. Boldt, Lewis, & Leander, 2015) and sensorial responses to digital texts (Rowell & Shillitoe, 2019). Stougaard Pedersen et al. (2021) proposed that 'a sensorially sensitive perspective' (p. 296) is essential for establishing a theoretically suitable framework for children's reading in the modern era. Connecting to this literature, Kucirkova (2022) proposed that the hidden senses of olfaction, gustation and proprioception might play a vital role in children's reading for pleasure and need to be investigated and theorized. Kucirkova and Tosun (2023) reviewed the extent to which children's picturebooks contain references to smell and concluded that in most popular children's books, smell references are used for entertainment purposes (e.g. elicitation of humour when something smells bad) rather than explored for their variety and enrichment potential. Apart from a few studies, the sense of gustation (Alaca, 2019) and the sense of proprioception (Mihelčič & Podlesek, 2017) have not been studied in reading. In this study, we examine the potential of the sense of smell (olfaction) in adult-child shared book reading at home.

Shared book reading (SBR hereafter) is in Western cultures considered part of everyday family lives and promoted as an activity 'par excellence' that parents can do to increase their children's learning (Sénéchal, 2017), notably in the areas of language (Crain-Thoreson & Dale, 1999), linguistic executive functioning (Howard, Powell, Vasseleu, Johnstone, & Melhuish, 2017), and socio-emotional skills (Bergman Deitcher, Aram, Khalaily-Shahadi, & Dwairy, 2021). SBR effects have been

documented with electronic books as well as print texts, although studies comparing print and digital books found differences in the quality of parents' language stimulation (Korat & Or, 2010; Parish-Morris, Mahajan, Hirsh-Pasek, Golinkoff, & Collins, 2013) and child's attention and concentration levels during reading (Arslan-Ari & Ari, 2021; Richter & Courage, 2017; but see Lauricella, Barr, & Calvert, 2014, for no difference between digital and paper storybook reading on child's outcomes). The strong focus on cognitive outcomes and adults' verbal stimulation during SBR, has meant that non-verbal communication and sensory stimulation during SBR have been neglected in previous research. Yet, it is likely that during book reading, children engage their sense of smell in various ways. For example, children can engage their sense of smell indirectly through textual and/or pictorial references included in the books' text, or directly through the release of an aroma from inside the book or around the reader in the reading space (ambient smell). Typical example of direct olfactory stimulation during children's reading are scratch-and-sniff books, which we used in the present study.

SBR with scratch-and-sniff books

Our interest in olfaction stimulated through scratch-and-sniff books stems from the theoretical premise that children's reading for pleasure can be supported through technological innovations, as demonstrated by the rapidly expanding literature on diverse story genres and formats offered to early readers (Biancarosa & Griffiths, 2012; Kucirkova & Cremin, 2020; Mackey, 2022). The use of scratch-and-sniff paperboard technology was popularized in the 1960s/1970s with a dedicated publishing line of classic children's titles (e.g. Cranberry Thanksgiving by Wende and Harry Devlin or the Little Golden Sniff It Books). Although the popularity of scratch-and-sniff books for children declined with the advent of digital books, examples of newly released titles reveal continuous readers' demand (e.g. The Truly Tasteless Scratch & Sniff Book by Dorling Kindersley, which imitates disgusting and nauseating smell or Instant Touch: A Tropical Scratch and Sniff by Belly Kids, that contains fruit aromas). Yet, the learning opportunities of scratch-and-sniff books are unknown.

Scratch-and-sniff books include pages with selected areas treated with a fragrant coating. When these areas are scratched, the odour is released. In this study, we selected the scratch-and-sniff book titled *Peter Follows His Nose* (Potter, 2020). The book is about a rabbit called Peter, who smells his way through the environment by sniffing and tasting various foods and herbs, such as lavender, strawberries, mushrooms, and onions. Each food item is mentioned in the story text, and it is represented with an illustrated image. This image is placed on top of, or next to, a scratch-and-sniff area under a small paper flap. When scratched, the aroma representing the specific foods and herbs is released from the page. We aimed to examine how such olfactory cues affect parent-child SBR at home.

Theoretical framework

Following Gibson's (1966) approach to relate sensory experiences to affordances in natural environments, we conceptualized the olfactory properties of scratch and sniff books as affordances that can take on different roles depending on how the parents and children activate them. Our understanding of the learning potential of such affordances is rooted in the socio-cultural theory (Vygotsky, 1987), according to which children learn through social and linguistic stimulation provided by the 'more knowledgeable other' (typically an adult) and the socio-cultural tool (such as an olfactory book in our case). During an activity, the adult and child co-construct knowledge, which is scaffolded by the adult within the child's zone of proximal development that is gradually stretched through the interaction and through the child's natural cognitive growth (Li & Fleer, 2015).

Our approach to SBR is framed by the Vygotskian tradition (Vygotsky, 1987). According to Vygotskian learning theory, activities such as SBR are an opportunity for adults to stretch children's learning in a zone of proximal development and mediate their understanding of new concepts. SBR is an

activity where adults' interaction influences the child and vice-versa, and this bidirectional influence fosters the child's interest and mediates the SBR learning outcomes (Petrie, Robert, Fei, & Montanari, 2023). Building on Vygotsky's theory, the transactional theory of reading (Rosenblatt, 1982) views reading as an active meaning-making process between reader(s) and text(s), shaped and influenced by the readers' active engagement with the texts and the texts' affordances. From this theoretical perspective, an olfactory book is a dynamic resource that readers 'transact' their meanings with. Vygotsky's and Rosenblatt's theoretical frames led us to pay equal attention to adults' and children's behaviours during SBR and to interpret their olfactory engagement as being socio-culturally contextualized and directly related to the tool that mediated their interaction, namely the olfactory book they shared.

While there are many analytical frameworks for parent-child interaction and verbal engagement of parents and children during SBR (see e.g. Justice, Weber, Ezell, & Bakeman, 2002), we could not locate an analytical tool suitable for adult-child interaction with an olfaction-stimulating resource. We therefore developed a new analytical framework focused on adult-child olfactory engagement.

Analytical framework

To guide our analysis, we derived three main principles from learning sciences applicable to SBR with olfactory books: multisensorium, contingency and embodiment.

Multisensorium

According to the multisensory learning principle, multi-sensory stimulation approximates natural settings where meaning is made by processing information via multiple sensory channels and is considered superior to learning via a single sensory channel, particularly for remembering new information (Blomert & Froyen, 2010; Shams & Seitz, 2008). The added value of multisensory processing is that of sensory integration, whereby the memory trace of, for example specific words or objects, is increased when perceived via multiple sensory channels (Thelen, Matusz, & Murray, 2014). Exploratory neurological studies suggest that learning platforms that capitalize on multi-sensory input *and* children's self-produced actions facilitate learning because they allow the visual and motor systems to interact and form important links for learning (James & Paroma, 2011). We were interested in occurrences that signal the engagement of all six basic senses – vision, hearing, touch, smell, taste, and proprioception (sense of body position and movement of limbs).

For visual engagement, we analysed the adult's and child's gaze directed towards the book. For hearing, we made an estimate based on the amount of spoken utterances during the coded session. For taste, we paid attention to the adult or child visibly chewing or eating during the observed interaction. For proprioception, we scrutinized the video recordings for movements across the room and bodily postures.

Contingency

SBR happens in a conversation between a child and an adult, typically the child's caregiver, and a central aspect of this conversation is the adult's socially contingent response to the child's behaviour and engagement in the activity (Bus, Van Ijzendoorn, & Pellegrini, 1995; Mol & Bus, 2011). Landry et al. (2012), for example, outline how responsive affective-emotional climate during SBR complements cognitively and linguistically stimulating reading strategies. Not all parents provide contingent support during SBR, and recent studies have explored how contingency could enhance children's learning through built-in technological interactions in digital books (Troseth, Russo, & Strouse, 2016). Such in-built digital contingency was shown to enhance how much mothers and children talked and how much their talk was attuned to each other in a study with 2-year-olds using the touchscreen technology (Okumura & Kobayashi, 2021). We hypothesized

that the olfactory stimulation in the scratch-and-sniff book could prompt contingent, or reciprocal, olfactory engagement by the adults and children.

Embodiment

The long tradition of cognitively and visually dominated reading studies has been recently challenged from a number of directions that have reflected the embodiment turn in reading (Trasmundi, Kokkola, Schilhab, & Mangen, 2021). Theoretical analyses of contemporary children's reading practices highlight the embodied rules of children's reading engagement (Stougaard Pedersen et al., 2021). Qualitative observational studies have shown the ways in which young children use their whole bodies in navigating stories in paper and on screen (e.g. Nicholas & Paatsch, 2021). With adult readers, Mangen (2016) has highlighted the importance of specific parts of body in embodied reading, notably the role of hands and fingers in turning pages, holding the book, and moving it closer and further from the eyes. Correspondingly, and with our focus on SBR of olfactory books, we considered the role of hands, fingers, and head in addition to the primary olfactory organ, the nose.

Olfactory behaviours

In addition to the broader principles derived from relevant literature, we drew on research that studied the interconnections between psychological and socio-cultural aspects in olfaction in both adults and children. In children's geography studies, which investigate the meaning of spaces in children's lives, we found references to children's experiences of various sensorial rhythms and intensities in urban and natural spaces, including the olfactory engagement of getting or catching a waft of a perfume, aroma, or scent by navigating cities and parks (Bourke, 2017; Cope, 2008; Degen, 2008). While these types of olfactory engagement have been alluded to in evaluating the sensory and emotional relations in urban landscapes (Degen & Rose, 2012), they have not been considered in relation to children's learning processes before.

Empirical evidence points to odour recognition independent of odour naming in adults (Croijmans, Arshamian, Speed, & Majid, 2021). Combining neurological and philosophical insights, embodied psychology and embodied cognition have introduced the importance of rhythm and space in perceptual behaviour (Claxton, 2015). Rapid perceptual processing involves two types of olfactory behaviours: whiffing and sniffing. Sniffing is a very rapid perceptual way of smelling (estimated to take about 200–300 ms, see Uchida, Kepecs, & Mainen, 2006), while whiffing involves several sniffs in succession that are used to build a perceptual image of a stimulus (Uchida et al., 2006; Gold & Shadlen, 2007). Sniffing and whiffing are similar to at-glance-viewing and a rapid perception to build a global image of a situation. It is possible that they are neurologically different types of smelling as they activate different brain parts, or different parts of the olfactory cortex (Sobel et al., 1998). Synthesizing this literature, we considered three types of olfactory engagement for our analytical framework: sniffing, whiffing and wafting. These were defined as: very brief inhaling through the nose (sniffing), smelling the stimulus strongly and intensely (whiffing) and using the hand or finger to let the odour pass through the air (wafting).

Study aims

We set out to document parent–child olfactory, non-verbal, engagement in SBR and map the engagement onto key learning principles. We also aimed to identify a typology of analytical dimensions that could be adopted for future empirical and pedagogical approaches to children's olfactory engagement. Our objective was not to intervene or establish universally applicable behaviours associated with specific types of smells or families, but rather to meticulously describe naturally occurring behaviours and offer researchers the necessary terminology, taxonomy and

perspective, for olfactory analyses. The study's two-pronged aim was pursued by answering two research questions:

- (1) What are the types and qualitative markers of adult-child olfactory engagement when reading scratch and sniff books?
- (2) How can multidisciplinary perspectives on SBR, olfaction and learning sciences be translated into a suitable typology of adult-child olfactory engagement?

Methods

Study participants

Given the largely exploratory nature of this study, purposive sampling method and snowball sampling technique were used to recruit the participants. Upon ethical permission received from the Norwegian Agency for Shared Services in Education and Research (NSD), we reached out to colleagues with children between three to five years via email and asked them whether they would be interested in participating in the study. We then used the snowball sampling method whereby the first participant recommended another potential participant and so on.

We used the snowball sampling method because it fitted with our aim to facilitate a deeper understanding of an unexplored research topic of olfaction and enhancing the richness of data (Woodley & Lockard, 2016). Similarly to other snowball sampling studies in qualitative research, we accessed participants from our existing social network and personal connections. We included all first ten participants who expressed an interest in the study given that all ten met our inclusion criteria of having a child in pre-school age and were willing to be video-recorded when reading a book with embedded odours.

Ten adult-child dyads participated in this study: nine female (eight mothers and one aunt) and one male (father) adults and seven boys and three girls with the youngest aged three years and the oldest five years. The families all lived in Western Norway and identified as native Norwegian speakers. All children were typically developing children, as declared by their parents when signing up for the study. The adults had substantial education as they were our indirect or direct university colleagues.

Ethical considerations

Our qualitative and exploratory study followed a socio-cultural approach to multi-faceted analyses of in-situ observations. We obtained the ethical permission from NSD to conduct the research and followed established procedures for educational inquiries, including seeking participants' ongoing and informed consent and prioritize the well-being and autonomy of family members by respecting their rights, values, beliefs, and cultural practices. The families were informed about the explorative nature of the study and our study aims. They were asked to sign a consent form and informed that they or their children can withdraw their consent anytime during the study. Upon analysis of the data, we sent the article draft to the families for possible revisions and verifications of accuracy. One participant expressed concern regarding anonymity and asked for the illustration that captured the engagement to be further blurred. Following this request, and given that we did not have the necessary illustration skills, we commissioned a professional illustrator who converted all illustrations into professional drawings. This satisfied the participant's request and the revised illustrations were also approved by all participants for publication.

Study procedure

The families were visited by the researcher (second author), who provided the families with two books, one that was a popular children's book about musical instruments and one that was the

scratch and sniff book *Peter Follows his Nose* (Potter, 2020), which was the target book in this study. The non-olfactory books were used for reference and to warm up the participants for the target book reading session. The observation was video recorded, from a quiet corner in the room where the families chose to read the books. The families were encouraged to read the books 'as they normally would at home' and were informed that our interest was in the adult-child interaction around diverse books. We emphasized to the families that we were interested in naturally occurring reading behaviours, that there were no right or wrong ways of reading and they could choose the family member to read with the child as per their normal reading routines.

The reading sessions lasted between 9 minutes 25 seconds to 22 minutes and 6 seconds. All books were covered in a single session. For most of the reading sessions ($n = 7$), the researcher did not film the interactions and instead gave detailed instructions to the families who borrowed the camera, placed it on a tripod in the room's corner and filmed the session themselves. This was a pragmatic decision aligned with our ethical stance in that we aimed to minimize any parent or child's discomfort and collect as authentic data as possible. For interactions where the researcher was present during filming ($n = 3$), the researcher was positioned outside of direct view of the interaction and kept her participation to a minimum or only spoke when directly asked a question by the family member or a child about one of the books.

We asked the families to begin the reading session with the child's favourite book, followed by the novel book about musical instruments and finally the olfactory book. This order was fixed across the participants as we assumed that starting with the child's favourite book would make the families more relaxed and thus lead to more natural behaviour during the SBR session.

To make the reading sessions as convenient and comfortable as possible, the families were free to decide the reading time (e.g. whether they chose to read in the evening, the afternoon; on a weekday or on a weekend).






Analytical approach

Development of the analytical framework

The development of our analytical framework occurred in three stages. First, we revisited SBR analytical frameworks focused on verbal parent-child interactions from the learning sciences perspective and noted some broader principles used in these frameworks that we deemed relevant for SBR learning with olfactory books. In Stage 1, we derived three main principles from learning sciences applicable to SBR with olfactory books: multisensorium, contingency and embodiment. In Stage 2, we drew on research from olfaction studies to establish engagement types that are typical to the activation of the sense of smell. Third, the learning principles established in Stage 1 and the concepts from olfaction studies in Stage 2 were operationalized and integrated into a workable coding framework focused on non-verbal engagement types.

Our research on non-verbal engagement was motivated by two primary justifications. Firstly, we sought to fill a significant gap in the existing literature, as no prior studies have specifically examined the non-verbal engagement of adults and children while reading scented books. Addressing this gap is crucial for developing a comprehensive understanding and vocabulary related to non-verbal engagement in this context. Secondly, non-verbal communication is widely recognized for its authenticity and its strong connection to interpersonal relationships (e.g. Ivy & Gleason, 2022). The study of parent-child communication examines the quality and reciprocity of both verbal and non-verbal interactions, with a focus on the relevance of contingent responses for studying engagement (see Masek et al., 2021). Accordingly, given our objective of exploring the reciprocal non-verbal engagement between adults and children during shared reading experiences, untainted by prior knowledge of smells or stories, we aimed to closely examine the immediate and authentic interactions that occur in families while reading scented books together.

Table 1. Qualitative portrayals of each family.

Family ID	Illustration	Description
Figure 1: Family 1		Child started by smelling with nose only, later started using finger. Mother used finger only. Mother smelled the page and her finger with which she scratched the olfactory area. Child smelled the pages only. Scratching surface was slow by mother and fast by child. Both scratched only shortly. Smelling was short and repeated according to the hotspots in the book for both.
Figure 2: Family 2		Child started by smelling the book cover before scratching it. She then used finger to scratch on the hotspots in the book. Child smelled strongly and intensely (whiffing); the duration of smelling behaviour was long and repeated. Mother smelled only shortly. The child placed whole head on the page when smelling. Mother placed only her nose on the page. Scratching surface was slow by mother and fast by the child. The mother scratched only shortly, while the child scratched for a longer period.
Figure 3: Family 3		The child asked the mother to scratch the page. The child barely scratched in the book herself. The smelling behaviour can mostly be characterized as sniffing by child and mother. Only rarely the behaviour can be characterized as whiffing by mother and child. Mother scratches fast and long to detect the scent on hotspots in the book. Proprioception is high for child – the child moves around on the sofa where the reading is situated.
Figure 4: Family 4		Both mother and child mostly smell their fingers or hands. They use their nose/whole head on page for smelling only occasionally. When using finger for smelling, they engage in sniffing, whiffing (only child) and wafting. More specifically, while mother smells only shortly, the child smells for a longer time using fingers or hands. A sibling enters the scene but the child remains focused on the smell in the book.
Figure 5: Family 5		Adult and child removed the stickers from the hotspots, and smelled the stickers instead of scratching them (see illustration), then the adult started scratching with her finger. Adult and child only smelled shortly and usually only once per page. At times, the child's smelling behaviour can also be characterized as whiffing. After reading the book, the child wanted to read it again.

(Continued)

Table 1. Continued.






Family ID	Illustration	Description
Figure 6: Family 6		Father smelled in short bursts, while the child smelled for longer periods and multiple times (repeated). The child used her finger to scratch the fragranced hotspots in the book. Speed of scratching was fast by the father and slow by the child.
Figure 7: Family 7		Mother smelled for short, while child smelled for longer periods. Uses of finger to scratch on the hotspots in the book. Quality of smelling was short for mother and long for the child.
Figure 8: Family 8		Length of smelling behaviour was short for the mother and long(er) for the child. Nevertheless, the smelling behaviour of both mother and child can be described as both sniffing and whiffing.
Figure 9: Family 9		Various smelling behaviours were demonstrated by both the mother and child, including use of fingers, approximating their heads to the page and smelling the entire book. Both mother and child's smelling behaviour can be described as sniffing, whiffing and wafting. Duration of the smelling behaviour was long and repeated for both mother and child.
Figure10: Family 10		The quality of smelling behaviour can be described as long and repeated for both mother and child. While both mother and child used their nose to smell the hotspots in the book, only the mother used her whole head to smell. Once they finished reading the book, the child wanted to read it again.

Table 2. Length, intensity, pace, embodiment and reciprocity of olfactory engagements.

Family ID	Length	Intensity	Pace	Only nose	Finger or hand	Whole head	Reciprocity
1 M c	Short <i>short</i>	Repeated <i>repeated</i>	Slow <i>fast</i>	No <i>yes</i>	Yes <i>yes</i>	No <i>yes</i>	75%
2 M c	Short <i>long</i>	Continuous <i>repeated</i>	Slow <i>fast</i>	Yes <i>yes</i>	No <i>no</i>	No <i>yes</i>	0%
3 M c	Short <i>short</i>	Repeated <i>repeated</i>	Fast <i>slow</i>	Yes <i>yes</i>	No <i>no</i>	Yes <i>yes</i>	50%
4 M c	Short <i>long</i>	Repeated <i>repeated</i>	Fast <i>slow</i>	No <i>no</i>	Yes <i>yes</i>	Yes <i>yes</i>	50%
5 M c	Short <i>short</i>	Continuous <i>continuous</i>	Slow <i>slow</i>	No <i>no</i>	Yes <i>yes</i>	Yes <i>yes</i>	10%
6 M c	Short <i>long</i>	Continuous <i>repeated</i>	Fast <i>slow</i>	No <i>yes</i>	No <i>no</i>	Yes <i>yes</i>	10%
7 M c	Short <i>long</i>	Continuous <i>continuous</i>	Fast <i>fast</i>	No <i>yes</i>	No <i>no</i>	Yes <i>yes</i>	10%
8 M c	Short <i>long</i>	Continuous <i>continuous</i>	Fast <i>slow</i>	Yes <i>no</i>	No <i>no</i>	Yes <i>yes</i>	10%
9 M c	Long <i>long</i>	Repeated <i>repeated</i>	Slow <i>slow</i>	No <i>no</i>	Yes <i>yes</i>	No <i>no</i>	100%
10 M c	Long <i>long</i>	Repeated <i>repeated</i>	Fast <i>fast</i>	Yes <i>yes</i>	No <i>no</i>	Yes <i>yes</i>	100%

Coding scheme

The third stage of developing our analytical framework consisted of transposing the SBR learning principles and concepts from olfaction studies to a workable coding framework and operationalizing them into a step-by-step approach. The definitions of the three non-verbal olfactory engagement types (sniffing, whiffing and wafting) were adopted from descriptions written for amateur and professional perfumers (Calkin & Jellinek, 1994; Van Toller & Dodd, 2012). To establish contingency, or reciprocity between adults and children, we were interested in the display of these olfactory engagements in both adults and children as well as the correspondence between their individual olfactory engagements. We considered embodiment in terms of adults and children using all their senses and engaging several body parts during reading. In addition, we considered the quality of each olfactory engagement type by drawing on Crescenzi's et al. (2014) descriptors of pace, length, and intensity of engagement.

Analytical procedure

The data were coded and analysed through a comparative method, with constant checking and discussion among the researchers to reach consensus and address discrepancies. The analysis occurred in two main stages. The first stage was the development of a log during the researchers' viewing of the video files. This log chunked the videos into one-minute-long segments. These segments were viewed and reviewed multiple times by both authors who made notes and independently thought about analytical categories. The notes were reviewed and content logs for a more fine-grained analysis were created. The second stage consisted of watching the videos again and categorizing them according to the pre-established definitions of the analytical framework. With frequent watching and re-watching and relatively short video segments, the videos were analysed directly by watching the sessions in the one-minute intervals. A session was defined as the interaction that lasted from first holding the olfactory book (either by the adult or child) to stopping the reading session by placing the book elsewhere or moving onto a different activity. The incidence of each type of engagement defined in the analytical framework was written down, using the one-minute-long segment as our unit of analysis.

Findings

To answer the first research question, a qualitative description of three main olfactory non-verbal engagement types in each adult-child dyad is presented, followed by a combined estimate of the

Table 3. Intensity of engagement of individual senses during olfactory reading collapsed across adult and child.

Family	Vision	Hearing	Touch	Smell	Taste	Propr.
1	H	M	H	H	L	M
2	H	M	H	H	L	M
3	M	M	M	H	L	H
4	H	M	H	H	L	M
5	M	M	H	H	L	M
6	H	M	H	H	L	M
7	M	M	H	H	L	H
8	H	M	M	H	L	M
9	H	M	H	H	L	M
10	H	M	H	H	L	M
Total	<i>High</i>	<i>Medium</i>	<i>High</i>	<i>High</i>	<i>Low</i>	<i>Medium</i>

quality of the adult–child olfactory engagement (length, intensity, reciprocity) and finally the extent of embodied olfactory engagement and multisensorial engagement for each dyad. For the second research question, we present a Typology of Olfactory Engagement that synthesizes the analytical categories, observed behaviours and theoretical insights.

Qualitative descriptions of families' olfactory engagement

In Table 1 and Figures 1–10 below and Table A1 in Appendix, we provide a short textual description of observed olfactory engagements in the form of our analysis notes, and a visual, illustrated, depiction of the typical olfactory engagement that we noted for each dyad. The illustrations are based on a video screenshot of a selected segment, which we considered to be most distinctive and representative of the most salient olfactory type of engagement in each family. Qualitative portrayals of each family are briefly described in Table 1 and illustrated in Figures 1–10.

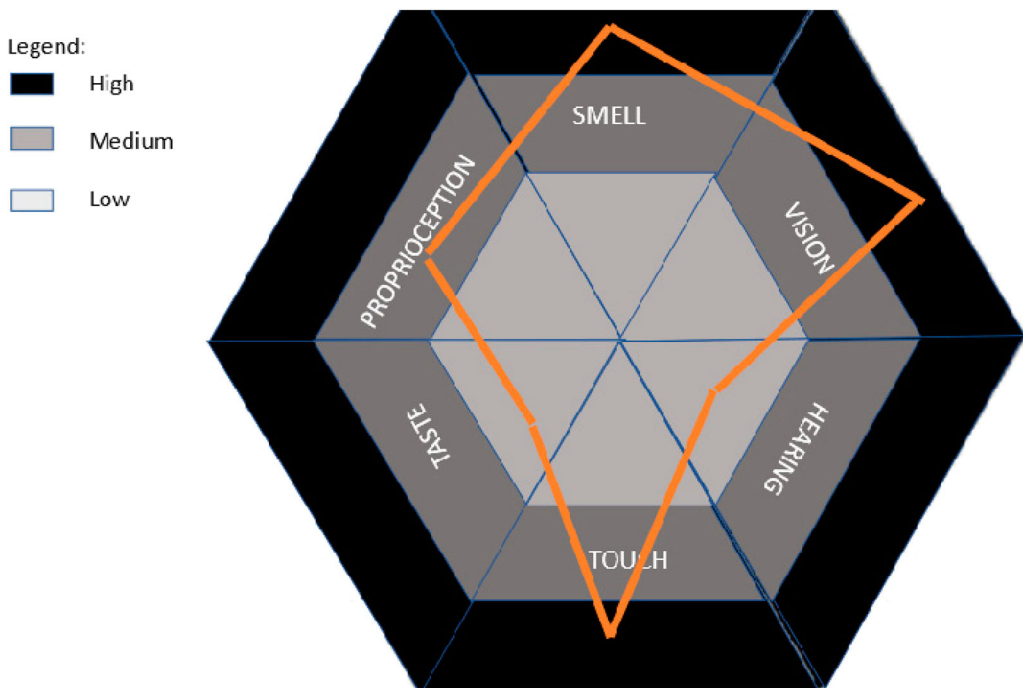
**Figure 1.** Spider diagram of intensity of engagement of individual senses across families.

Table 4. Typology of olfactory engagement.

Aspect	Description	Type of assessment
Olfactory behaviours		
Sniffing	A perception of the olfactory area by inhaling through the nose a few seconds	Presence within a given observation interval
Whiffing	Smelling the stimulus strongly and intensely, with at least two sniffs	Presence within a given observation interval
Wafting	The adults and children using their hand, head or finger to let the scent pass gently through the air	Presence within a given observation interval
Quality of olfactory engagement		
Length	The relative duration of a specific smelling behaviour observed within the interval, with long being more than 75% of the observed interval and short less than 25%	Long/Short within a given observation interval
Intensity	The repetition of an observed smelling behaviour, with an occurrence of the same engagements considered to be repeated if they occur more than two times within an observed interval	Continuous/ Repeated within a given observation interval
Pace	The relative pace of an olfactory engagement type, with bodily movements considered to be fast when the velocity is comparable to running pace	Fast/Slow within a given observation interval
Contingency	Correspondence or reciprocity between adults' and children's behaviours	Percentage of match between adult and child
Embodiment	Somatic indicators of the use of nose, finger, hand and head in the observed interval	Arbitrarily observed use of one or more body parts in the observed interval
Multisensorium		
Rapid, naked-eye observable assessment of engagement of all six senses		
Vision	Visual attention to the book as an object, observed as eye gaze and looks oriented towards the book's pages or cover	Yes/No
Hearing	Activated through verbal engagement of the readers; Audio or noise levels observable during the interaction	Yes/No
Touch	Physical manipulation of the book by fingers, hands or other body parts	Yes/No
Smell	Smelling behaviour indicated by the use of nose	Yes/No
Gustation	Visible use of mouth or tongue during the activity, for example the participant eats or chews.	Yes/No
Proprioception	Movements of limbs or whole body during the activity	Yes/No
Intensity	The occurrence of engagement of each sense is considered High when the sense dominates an observed interval, Medium when the sensorial aspect is present during the observed interval and Low when it is minimal or absent.	High, low, medium

Quality estimates of olfactory engagement

The quality estimates focus on the length with which the adults and children scratched the olfactory surfaces (long and short), frequency of scratching (continuous or repeated), duration of scratching (short or long) and the pace of scratching (slow or fast) during the session. For *Embodied Engagement*, we noted the use of nose, finger, hand and head as either being present or not during the interaction, by both the child and the adult. *Reciprocity* was calculated as agreement between dichotomous scores (see Stiffman et al., 2000), that is the correspondence between the adults' and children's display of one of the quality characteristics of their olfactory engagement (with complete match being 100% and complete mismatch 0%). Table 2 captures the estimates for each child (c) and adult (M) in the sample.

Multisensorial engagement

Table 3 shows how we denoted the intensity for sensory engagement as High, Medium and Low (with high being more than 70% of the observed interval time, Medium between 30–70% and Low under 30%) and calculated the combined intensity of engagement with each sense across the families with the most frequent one included in the final 'total' score. This combined score of

multisensorial engagement in the families is represented in a condensed visual form with a spider diagram, which facilitates an at-glance view of results (see Howse, Stapleton, & Taylor, 2005). In the spider diagram, each sense is distributed evenly around the wheel, with the distance closer to the centre of the wheel indicating closer to zero (Figure 1).

Typology of olfactory engagement

Our Typology of Olfactory Engagement was established by synthesizing the theoretical insights from the development of the analytical framework and its application to our data. As shown in Table 4, the typology comprises analytical dimensions connected to Olfactory behaviours, Quality of olfactory engagement, and three learning principles of Contingency, Embodiment, and Multisensorium.

Discussion

Vannini, Waskul, and Gottschalk (2013) wrote that the socio-culturally dependent arrangement of sensoria (the hierarchical 'sensory order', p. 59) does not correspond to the complexity of learning. We followed their call for not imposing hierarchies on sensory experiences and examined adult-child olfactory engagement in a typical learning activity occurring in Norwegian families. Scratch-and-sniff books have not been considered in the shared book reading literature before, and we have documented how they prompted olfactory engagements of adults and children reading them together at home. We found that the adults and children engaged in three different types of olfactory engagement (sniffing, whiffing and wafting) and they smelled for relatively long intervals, with repeated scratching and sniffing of the olfactory areas, at a relatively high pace. The reciprocity between adults' and children's olfactory engagements varied from no attunement to fully contingent responses. The most intensively engaged senses across the dyads were touch, vision and smell and the adults and children frequently used not only their nose but also fingers, hands and whole head to smell the book.

In terms of embodiment, we found that smelling by approximating their nose to the page was common for both adults and children, but some also smelled their hands and finger instead of the pages. Seven mothers and almost all (nine) children smelled the page by placing their head inside the book at some point during the session. All participants scratched the scented surface with their fingers and fingernails and three children also with their whole hand. The scratching was mostly long, approximately more than five seconds in duration per each scented page. Overall, the findings highlight a tendency of all families to engage in olfactory behaviours, but the type and quality of the smelling behaviour was different between and within families. We underscored the idiosyncrasy of the olfactory engagement of each dyad by composing olfactory profiles of families, which can be used for comparative purposes in future studies.

Great variability in olfactory performance has been noted in both adult and child populations as part of clinical assessment of various conditions, for example adults with a history of anorexia (Rapps et al., 2010) or children with autism (e.g. Dudova et al., 2011). Our heterogenous findings indicate that the patterns of adult-child olfactory engagement during SBR are likely to vary and might need to be viewed in light of the unique social and cultural associations people have with different odours (Classen, 1992; Classen, Howes, & Synnott, 2002). We agree with Almagor (1990) that 'some aspects of odour sensation resemble the notion of a "private language"' (p. 255). In our study with ten parents, there were five families that engaged in different olfactory behaviours in terms of pace, intensity and quality of smelling. As such, we observed that the olfactory private language seemed to be spoken separately by adults and children while they read together.

The summative engagement of the sense of smell was high, indicating that introducing an olfactory book into SBR sessions might alter the intensity of adults' and children's sensorial engagement during reading. This indicates that SBR with scratch-and-sniff books might be used to target the olfactory engagement in families and thus shape future methods and pedagogies in the area of

shared book reading. To this end, our proposed Typology of Olfactory Engagement can be used for expanding future observational studies of parent–child interactions. For example, the Typology could be used for examining verbal olfactory engagement and its possible correspondence to non-verbal engagement, types of smells and types of families. Once more widely used, the system could be improved with insights from diverse types of olfactory resources and their use with diverse families. While deep insights are gained from language and verbal communication, the engagement of other senses, such as the olfactory senses, can provide new insights into the mechanisms and effects of learning during SBR. The proposed typology addresses the need for systematically describing parent–child olfactory engagement.

Study limitations

Given the qualitative research design, our findings are indicative and not conclusive. Following the interpretation framework of the socio-cultural and transactional theories, the qualitative markers of adult–child olfactory engagement, such as the long, repeated and fast smelling could be attributed to the book's affordances as well as the unique characteristics of each family. Notably, the relatively faint smell of the scratch-and-sniff areas in the book, as well as the adults' and children's unfamiliarity with reading olfactory books and the participants' individual thresholds for odour identification (see Boesveldt, Verbaan, Knol, Van Hilten, & Berendse, 2008), might have influenced the results. Future studies could expand our work with a study of various types of olfactory books to better understand how different olfactory stimulations affect the interplay of senses in the readings and individual preferences for various kinds of smells.

Another limitation of our study is the fact that all participating families were native Norwegians connected to the University. The homogeneity of the group was somewhat addressed with the invitation to engage in reading by any family member and hence, it was not only mothers but also a father and an aunt engaging in reading. SBR has been mostly studied with mothers, but recent studies show there are more similarities rather than differences between mothers and fathers reading with their children (Tamis-LeMonda, Baumwell, & Cabrera, 2013). Future research could usefully expand our analysis with diverse families and the various types of books they use. Although it would be difficult to find a suitable comparison condition, it would be interesting to explore how family engagement with olfactory books compares to other types of books they read. In this study, we specifically focused on behavioural markers of olfactory engagement, but in a related study, we examine the verbal engagement by adults and children when reading olfactory books together.

Future directions

The importance of greater scientific attention to the role of sense of smell was noted in relation to neurodegenerative diseases such as the Parkinson's (Hoyles & Sharma, 2013) and Alzheimer's disease (Murphy, 2019) and more recently in recovery plans for Covid-19 patients (Walker, Hopkins, & Surda, 2020), but has not been pursued in learning sciences. Yet, the sense of smell is implicated in perceptual learning (Spence, 2019) and key learning processes. For example, odour knowledge, particularly verbal odour identification, activates short-term and working memory processes (Schecklmann et al., 2013) and olfactory language can be learnt, especially if the odours are part of familiar experiences such as coffee drinking (Huisman & Majid, 2018). The instances of olfactory engagement we noted in our participants describe the dimensions of shared book reading that are unique to an olfactory focus. The Typology of Olfactory Engagement pays close attention to the principles of embodied, contingent and multisensorial learning and serves as a starting point for developing the metrics of olfactory engagement. Overall, our study is the first to focus on olfactory engagement in early reading and as such, charts new directions for studying the role of smell in children's everyday reading experiences.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by The Norwegian Research Council, grant nr. 31411.

Notes on contributors

Natalia Kucirkova is Professor of Early Childhood Education and Development at the University of Stavanger, Norway. Her work is concerned with social justice in children's literacy and innovative uses of technologies. Her latest research project uses participatory approaches and examines the value of children's sensory, and in particular, olfactory, engagement in stories.

Ida Bruheim Jensen holds a PhD in social work and works as an Associate Professor at the Department of Social Studies, University of Stavanger. Her research interests are multi-faceted, comprising social work with vulnerable children and families, technology and social work, early literacy and research with children.

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Appendix

Table A1. Short descriptive information about each family's olfactory profile.

Family ID	Description
1	Child started by smelling with nose only, later started using finger. Mother used finger only. Mother smelled the page and her finger with which she scratched the olfactory area. Child smelled page only. Scratching surface was slow by mother and fast by child. Both scratched only shortly. Smelling was short and repeated according to the hotspots in the book for both.
2	Child started by smelling the book cover before scratching. Then used finger to scratch on the hotspots in the book. Child smelled strongly and intensely (whiffing), duration of smelling behaviour was long and repeated. Mother smelled only shortly. The child placed whole head on the page when smelling. Mother only nose on the page. Scratching surface was slow by mother and fast by child. Mother scratched only shortly, while child scratched for a longer period.
3	The child asked the mother to scratch. The child barely scratches in the book herself. The smelling behaviour can mostly be characterized as sniffing by child and mother. Only rarely the behaviour can be characterized as whiffing by mother and child. Mother scratches fast and long to detect the scent on hotspots in the book. Proprioception is high for child – moves around in the sofa where the reading is situated. Vision is characterized as moderate by child, as the smelling hotspots seem more interesting than illustrations in book.
4	Both mother and child mostly smell their fingers or hands. They use their nose/whole head on page for smelling only occasionally. When using finger for smelling, they engage in sniffing, whiffing (only child) and wafting. More specifically, while mother smells only shortly, the child smells for a longer time using fingers or hands.
5	Adult and child removed the stickers from the hotspots, and smelled the stickers instead of scratching (see illustration), then the adult started scratching with her finger. Adult and child only smelled shortly and usually only once per page (hence, short, and continuous). At times, the child's smelling behaviour can also be characterized as whiffing. Once they are finished reading the book, the child wants to read it again.
6	Father smelled in short bursts, while the child smelled for longer periods and multiple times (repeated). The child used her finger to scratch the fragranced hotspots in the book. Speed of scratching was fast by the father and slow by the child.
7	Mother smelled for short, while child smelled for longer periods. Uses of finger to scratch on the hotspots in the book. Quality of smelling was short for mother and long for the child. Proprioception was high for the child – moved around in the bed where the reading was situated. Vision was characterized as moderate for the child, as smelling the hotspots seemed more interesting than looking at the book illustrations.
8	Length of smelling behaviour is short for the mother and long(er) for the child. Nevertheless, the smelling behaviour of both mother and child can be described as both sniffing and whiffing. Vision is characterized as high by child as child seems very concentrated on book content.
9	Various smelling behaviours were demonstrated by both the mother and child, including use of fingers. Both mother and child's smelling behaviour can be described as sniffing, whiffing and wafting. Quality of smelling behaviour is described as long and repeated for both mother and child.
10	Quality of smelling behaviour is described as long and repeated for both mother and child. While both mother and child used their nose to smell the hotspots in the book, only the mother used her whole head to smell. Once they finished reading the book, the child wanted to read it again.